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DEPARTMENT OF ENGINEERING

NEWS

UNIVERSITY OF CAMBRIDGE

In this issue

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Cover image: Alumnus Alex Kendall, Wayve co-founder and CEO. Credit: Wayve

Note from the editors

Welcome to another edition of the Department Newsletter.

A recent conversation with one of our alumni prompted us to encourage more of you to join our LinkedIn alumni group at www.linkedin.com/groups/127740

The group currently has 4,300 members and is growing steadily.

You may find the group an interesting place.

You can message other alumni. Strike up conversations. Build relationships with other professionals who share your interests.

Exchange knowledge, ask questions, and find answers. A place to network helping you connect with industry experts, maybe offer or find career advice.

A place to post and view job opportunities.

Cambridge University Engineers' Association (CUEA) use the alumni group to post about industrial placement opportunities, requests for mentors for their mentoring scheme and advertise CUEA talks and events.

A LinkedIn group can be a useful resource and a valuable community. It is what we make it.

We hope to see more of you there.

Charlotte Hester and Jacqueline Saggers
Email: marketing@eng.cam.ac.uk

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Head's welcome

Welcome to this latest edition of the Department of Engineering News for Autumn 2024.

There have been some significant developments since the last edition earlier this year. The Engineering MoveWest programme is fully back on track with architects and planners looking at scoping out the requirements for the Department on the Cambridge West campus. The planned total redevelopment of the Roger Needham Building for Engineering is progressing towards RIBA stage 2 now. Construction on the new Whittle Lab is well-advanced, with a topping-out ceremony having taken place in September.

In other news, we are embarking on introducing a new MPhil in Electrical Engineering in around two years' time, which is specifically aimed at filling the skills shortage in this sector in the UK, alongside our existing Tripos of course.

The planned reform of Part I continues to move forwards, with broad agreement on the overall structure, which will enable much tighter integration between lectures and labs, and now more recently looking at the specific content. The plan is still to introduce this in Michaelmas 2026.

As a department, we continue to evolve and have just appointed faculty in areas related to Computer Vision and Energy, as well as Optical Engineering, all just started or due to start in the coming months.

Looking through this edition of the newsletter, the cover story on **page 9** outlines the pioneering work being carried out by Alex Kendall, who went on to co-found Wayve, which is leading the way in developing embodied AI for autonomous driving. Alex will be delivering an open lecture in the Department as our first 150th anniversary event, on November 21st.

Next you will see the story on **page 4** about Professor Julian Allwood's game-changing invention of a technique to recycle cement in an ultra-low emission process, which is a major step towards net zero concrete.

On **page 7** you will see the story of the work carried out by Professor George Malliaras along with collaborators from Neuroscience and clinicians, on the use of flexible, implantable electronics to help patients with spinal cord injuries.

On **page 14** is an inspiring update on how some of our Mastercard Foundation Scholars continue to make a difference and contribute to climate resilience and sustainable futures in Africa.

Then on **page 12** is an article where our very own Head of Design and Technical Services, Thomas Glenday, recreated the historic Venn cricket bowling machine, using a design from over 100 years ago.

Throughout the rest of the newsletter, you will see a range of stories about faculty, alumni and undergraduates, and I hope you will find something interesting.

Professor Colm Durkan FIET, FInstP

Credit: Materials Processing Institute

Cement recycling method could help solve one of the world's biggest climate challenges

Researchers have developed a method to produce very low-emission concrete at scale – an innovation that could be transformative in the transition to net zero.

The method uses the electrically powered arc furnaces used for steel recycling to simultaneously recycle cement, the carbon-hungry component of concrete.

Concrete is the second-most-used material on the planet, after water, and is responsible for approximately 7.5% of total anthropogenic CO_2 emissions. A scalable, cost-effective way of reducing concrete emissions while meeting global demand is one of the world's biggest decarbonisation challenges.

The researchers found that used cement is an effective substitute for lime flux, which is used in steel recycling to remove impurities and normally ends up as a waste product known as slag. But by replacing lime with used cement, the end product is recycled cement that can be used to make new concrete.

The method, reported in the journal *Nature*, does not add any significant costs to concrete or steel production and significantly reduces emissions from both concrete and steel, due to the reduced need for lime flux.

Recent tests carried out by the Materials Processing Institute, a partner in the project, showed that recycled cement can be produced at scale in an electric arc furnace (EAF), the first time this has been achieved. Eventually, this method could produce zero emission cement, if the EAF was powered by renewable energy.

Concrete is made from sand, gravel, water, and cement, which serves as a binder. Although it's a small proportion of concrete, cement is responsible for almost 90% of concrete emissions. Cement is made through a process called clinkering, where limestone and other raw materials are crushed and heated to about 1,450°C in large kilns. This process converts the materials into cement but releases large amounts of CO_2 as limestone decarbonates into lime.

Over the past decade, scientists have been investigating substitutes for cement, and have found that roughly half of the cement in concrete can be replaced with alternative materials, such as fly ash, but these alternatives need to be chemically activated by the remaining cement in order to harden.

"It's also a question of volume – we don't physically have enough of these alternatives to keep up with global cement demand, which is roughly four billion tonnes per year," said Professor Julian Allwood, who led the research. "We've already identified the low hanging fruit that helps us use less cement by careful mixing and blending, but to get all the way to zero emissions, we need to start thinking outside the box."

"I had a vague idea from previous work that if it were possible to crush old concrete, taking out the sand and stones, heating the cement would remove the water, and then it would form clinker again," said first author Dr Cyrille Dunant. "A bath of liquid metal would help this chemical reaction along, and an EAF, used to recycle steel, felt like a strong possibility. We had to try."

The clinkering process requires heat and the right combination of oxides, all of which are in used cement, but need to be reactivated. The researchers tested a range of slags, made from demolition waste and added lime, alumina and silica. The slags were processed in the Materials Processing Institute's EAF with molten steel and rapidly cooled.

"We found the combination of cement clinker and iron oxide is an excellent steelmaking slag because it foams and it flows well," said Dr Dunant. "And if you get the balance right and cool the slag quickly enough, you end up with reactivated cement, without adding any cost to the steelmaking process."

The Cambridge Electric Cement process has been scaling rapidly, and the researchers say they could be producing one billion tonnes per year by 2050, which represents roughly a quarter of current annual cement production.

"Producing zero emissions cement is an absolute miracle, but we've also got to reduce the amount of cement and concrete we use," said Professor Allwood.

Written by Sarah Collins

Open access paper:
www.eng.cam.ac.uk/cementrecycling
Watch the video:
youtu.be/MqWXXLOCeNg

Credit: Adam Page/University of Cambridge

→ Dr Dante McGrath (left), winner of the Falling Walls Lab Cambridge 2024, meets last year's winner, and jury member Yizhou Yu, Founder of Healthspan Biotics

Showcasing breakthrough research that creates a positive impact on science and society

Postgraduates and postdocs of all disciplines from the Universities of Cambridge, Bolton, Strathclyde and Manchester, were challenged to pitch their innovative ideas at the Falling Walls Lab Cambridge – in just three minutes.

Falling Walls Lab is a global interdisciplinary pitch competition for students and early-career professionals to showcase a breakthrough that positively impacts science and society. It is an opportunity to gain exposure for an idea, strengthen communications skills, and foster networking and collaboration.

Among the 11 presenters pitching to an audience, including a panel of judges, were three presenters with affiliations to the Department of Engineering – hosts of the event. They were:

- Dr Dante McGrath. Presentation title: *Breaking the wall of the melting Arctic*
- PhD student Richard Marques Monteiro. Presentation title: *Breaking the wall of AI language learning*
- Dr Ali Doryab. Presentation title: *Breaking the wall of lung drug development*

Dr McGrath, Research Associate in Marine Cloud Brightening at the Centre for Climate Repair, was announced as the winner of the Lab. He will go forward to compete in the Falling Walls Lab finale to be held in Berlin, Germany, this November. He was also announced as the audience award winner.

Dante said: "My research concerns interventions that may limit the impact of global warming on Earth's ecosystems. The Arctic is an ecosystem in a state of rapid decline. Sea ice is melting at an alarming rate. The consequences of a melting Arctic are local and global. The perilous state of the Arctic presents the need to consider interventions to complement existing climate mitigation strategies.

"One such intervention is known as marine cloud brightening. The concept involves the delivery of salt particles into marine clouds to reflect more sunlight. Clouds and aerosols have the ability to cool the Earth's surface, counteracting the warming from greenhouse gas emissions. Delivering salt of optimal size and quantity into clouds may boost their ability to reflect heat.

"At the Centre for Climate Repair, we are developing a droplet generation system to generate and deliver optimal salt particles in a safe, scalable, and energy-efficient manner. These criteria present engineering hurdles, hurdles that must be cleared for the concept to be deemed technologically viable."

He added: "In addition to our research, we regularly communicate with people outside our domain, including indigenous leaders, policymakers, social scientists, and youth representatives. These discussions lay a foundation of understanding on which climate interventions may be assessed from multiple viewpoints.

"Events such as these are valuable opportunities for early-career researchers to step out from their silos and communicate their work to a wide audience. The experience was both energising and inspiring."

The runner-up was Gates Cambridge Scholar Mahlaqua Noor, who is studying for a PhD in Medicine, with her presentation titled *Breaking the wall of the unshakable virus*.

Third place went to PhD student Bayu Sutanto from the University of Manchester, with his presentation titled *Breaking the wall of floating PV investment*.

Read the full article at:
www.eng.cam.ac.uk/falling-walls-2024

Watch the pitches:
https://bit.ly/3Tbb8el
www.climaterepair.cam.ac.uk

→ From left, Maxime Burgonse (CTO), Nadeem Gabbani (CEO) and Peter J. Christopher (CSO)

ALUMNI UPDATE

Satellite manufacturer Exobotics founded by three alumni

Late 2018, during their PhDs in the Department of Engineering, three friends started a satellite manufacturing company called Exobotics. In 2020, they won their first funding. In 2022, they delivered their first satellites. In 2024, they are on a mission to make space accessible to everyone.

When Nadeem Gabbani founded Exobotics in 2018 and needed some volunteers to help him, he recruited his friends Maxime Burgonse and Peter J. Christopher to assist.

Speaking about the team, Professor Bill O'Neill says: "Having observed their relentless innovation and determination over many years, Nadeem and his team have transitioned from shaping theories to executing them in the space industry. This impressive leap from academia to entrepreneurship not only highlights their profound expertise, but also celebrates their ability to transform academic excellence into groundbreaking industry leadership. Congratulations on pioneering such a remarkable venture – it's a testament to your vision and hard work."

We caught up with Peter to find out more.

What is the background of Exobotics?

We're a satellite manufacturing company. We started up in late 2018 as a group of three Cambridge Engineering PhD students and have been growing steadily ever since.

Please explain the services and products that you offer and the sorts of projects you work on.

Exobotics manufactures high-tech satellites for a range of customers. We're growing rapidly and will be launching four satellites in the next nine months.

Our mission is to work closely with high-tech companies and help them to put their technology payloads into space. We're pretty much unique in how fast we can do this and we've taken missions from concept to delivered satellite in less than nine months, less than half the industry standard. We are extremely focused on customer service and integration with our partners to ensure project success.

What will be the potential real-world impact of your technology?

Space is one of the fastest growing sectors in the UK economy, with a massive downstream impact for consumers and businesses alike. Many of the technologies we rely on today are underpinned by satellite technology, from GPS to climate monitoring. Excitingly, we've seen phenomenal growth in innovation and investment into the new space technologies being developed globally, particularly in the UK.

Where Exobotics fits in is the delivery and we work closely with our customers, deploying their technology into space by designing and building satellites around their payloads. We can then test and operate these to give an end-to-end package for our customers and allow them to remain focused on their own technology.

We take your technology and put it into space for you.

What are your future goals?

Bigger, faster, stronger! We've got a schedule of satellites and satellite constellations coming up. A large part of our pitch to our customers is that we provide best-in-class technology and we're working hard to extend our portfolio and the range of capabilities of our flagship XO-BUS satellite design. We're also significantly increasing our manufacturing capacity so we can build and operate constellations of larger satellites.

Most importantly, we already get to work with some of the most cutting-edge space companies and organisations in the world and we're excited to carry on doing this!

> "Many of the technologies we rely on today are underpinned by satellite technology, from GPS to climate monitoring. Excitingly, we've seen phenomenal growth in innovation and investment into the new space technologies being developed globally, particularly in the UK.
>
> Peter J. Christopher, CSO at Exobotics

Read the full article at:
www.eng.cam.ac.uk/exobotics

→ Illustration of spinal cord

PIC4U – stock.adobe.com

‘Wraparound’ implants represent new approach to treating spinal cord injuries

A tiny, flexible electronic device that wraps around the spinal cord could represent a new approach to the treatment of spinal injuries, which can cause profound disability and paralysis.

A team of engineers, neuroscientists and surgeons from Cambridge developed the devices and used them to record the nerve signals going back and forth between the brain and the spinal cord. Unlike current approaches, the Cambridge devices can record 360-degree information, giving a complete picture of spinal cord activity.

Tests in live animal and human cadaver models showed the devices could also stimulate limb movement and bypass complete spinal cord injuries where communication between the brain and spinal cord had been completely interrupted.

Most current approaches to treating spinal injuries involve both piercing the spinal cord with electrodes and placing implants in the brain, which are both high-risk surgeries. The Cambridge-developed devices could lead to treatments for spinal injuries without the need for brain surgery, which would be far safer for patients.

While such treatments are still at least several years away, the researchers say the devices could be useful in the near-term for monitoring spinal cord activity during surgery. Better understanding of the spinal cord, which is difficult to study, could lead to improved treatments for a range of conditions, including chronic pain, inflammation and hypertension. The results are reported in the journal *Science Advances*.

“The spinal cord is like a highway, carrying information in the form of nerve impulses to and from the brain,” said Professor George Malliaras from the Department of Engineering, who co-led the research. “Damage to the spinal cord causes that traffic to be interrupted, resulting in profound disability, including irreversible loss of sensory and motor functions.”

The ability to monitor signals going to and from the spinal cord could dramatically aid in the development of treatments for spinal injuries, and could also be useful in the nearer term for better monitoring of the spinal cord during surgery.

“Most technologies for monitoring or stimulating the spinal cord only interact with motor neurons along the back, or dorsal, part of the spinal cord,” said Dr Damiano Barone from the Department of Clinical Neurosciences, who co-led the research. “These approaches can only reach between 20 and 30 per cent of the spine, so you’re getting an incomplete picture.”

By taking their inspiration from microelectronics, the researchers developed a way to gain information from the whole spine, by wrapping very thin, high-resolution implants around the spinal cord’s circumference. This is the first time that safe 360-degree recording of the spinal cord has been possible – earlier approaches for 360-degree monitoring use electrodes that pierce the spine, which can cause spinal injury.

The Cambridge-developed biocompatible devices – just a few millionths of a metre thick – are made using advanced photolithography and thin film deposition techniques, and require minimal power to function.

The devices intercept the signals travelling on the axons, or nerve fibres, of the spinal cord, allowing the signals to be recorded. The thinness of the devices means they can record the signals without causing any damage to the nerves, since they do not penetrate the spinal cord itself.

The devices were implanted using an adaptation to routine surgical procedure so they could be slid under the spinal cord without damaging it. In tests using rat models, the researchers successfully used the devices to stimulate limb movement. The devices showed very low latency – that is, their reaction time was close to human reflexive movement. Further tests in human cadaver models showed that the devices can be successfully placed in humans.

Written by Sarah Collins

Open access paper:
www.eng.cam.ac.uk/spinal-cord

Credit: LEFT: TripleP Studio – stock.adobe.com. RIGHT: Hughes Hall / Martin Bond

Engineers lead prize-winning idea to tackle societal challenges using AI

↑ Dr Kwadwo Oti-Sarpong, AI-deas challenge lead

Dr Kwadwo Oti-Sarpong, Senior Research and Teaching Associate at the Cambridge Centre for Smart Infrastructure and Construction (CSIC), leads a multidisciplinary team announced as a winner of the 'AI-deas' challenge – a new University prize supporting ambitious ideas for how AI can address critical societal issues.

The winning project titled *Decision-making with AI in connected places and cities* will develop resources for local authorities to make ethical and informed decisions about the use of AI in their digitalisation initiatives. The project is one of five winners selected by ai@cam: the University's new flagship mission to drive AI innovation that benefits science, citizens and society.

The team comprises Jennifer Schooling (Professor of Digital Innovation and Smart Places, Anglia Ruskin University; Former Director of the CSIC); Dr Viviana Bastidas and Dr Manuel Herrera (Department of Engineering); Dr Li Wan and Dr Jerry Chen (Department of Land Economy); Dr Ramit Debnath (Department of Architecture and Cambridge Zero); and Dr Maya Indira Ganesh (Leverhulme Centre for the Future of Intelligence).

Public sector use of AI is growing, with some local authorities in England already using large language models and predictive analytics to make city-scale decisions.

"It is important that the use of AI to make decisions is ethical and leads to the desired outcomes," said Dr Oti-Sarpong.

The project aims to investigate how local authorities in England are using AI to make decisions about issues such as placemaking (a collaborative process for shaping public space), land use and mobility, and sustainable water supply systems to create public value. ai@cam has provided seed funding to get the project off the ground and support to scale its impact.

The Department of Engineering is leading this project, collaborating with local authorities and experts in other domains including urban governance, philosophy and ethics.

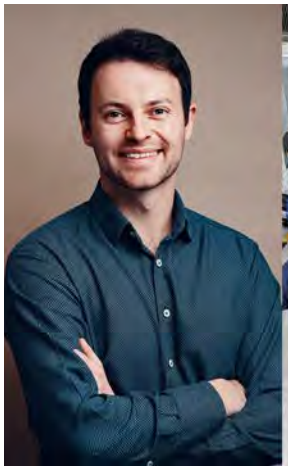
"We are excited to be one of the winners of AI-deas and looking forward to working on this project with practitioners across disciplines to shape the future of public sector decision-making using AI in creating connected places," said Dr Oti-Sarpong. "Understanding how to practically root AI use in ethical considerations, and showing how that can be done, will significantly change how we create the future we want."

AI-deas is ai@cam's first major initiative and will form part of a wider programme designed to deliver on the University's AI mission. Through research funding, partnerships within and outside of the University, and education, ai@cam will more powerfully connect what happens in the University lab to the outside world.

> "Understanding how to practically root AI use in ethical considerations, and showing how that can be done, will significantly change how we create the future we want."
>
> Dr Kwadwo Oti-Sarpong

Read the full article at:
www.eng.cam.ac.uk/challenges-ai
ai.cam.ac.uk/
www-smartinfrastructure.eng.cam.ac.uk

→ LEFT: Alumnus Alex Kendall, Wayve Co-founder and CEO. RIGHT: The Wayve team



Credit: Wayve

Wayve – a pioneer in embodied AI for autonomous driving – raises $1bn in new funding round

UK AI company Wayve – co-founded by alumnus Alex Kendall in 2017 while studying for his PhD at Cambridge – has secured more than $1 billion to develop AI for self-driving vehicles.

Backed by SoftBank Group, NVIDIA and Microsoft, this announcement (made in May 2024) marks the biggest investment in a UK AI company in history, and will see Wayve use the $1.05 billion to develop and launch the first "embodied AI" technology for self-driving vehicles in the UK.

Embodied AI will enable self-driving (otherwise known as automated) vehicles to learn from and interact with a real-world environment, including the ability to navigate and learn from situations that do not follow strict patterns or rules, such as unexpected actions by drivers or pedestrians – going far beyond the capabilities of existing AV technology.

Wayve has said that their advancements in self-driving vehicle technology have been supported by the UK's Code of Practice: Automated Vehicle Trialling, which sets out a clear framework to support and promote the safe trialling of self-driving vehicle technology.

It was during Alex's PhD in Deep Learning, Computer Vision and Robotics, under the supervision of Professor Roberto Cipolla in the Machine Intelligence Laboratory, that the groundwork for what would become Wayve began to take shape.

And in November this year, Alex, Wayve CEO, is due to return to Cambridge to give a talk at the Department of Engineering as part of the Department's 150th anniversary celebrations. A recording of this talk will be made available online.

Read the full article at:
www.eng.cam.ac.uk/wayve-ai

Hubs launched to ensure UK benefits from quantum future

Major new research hubs involving the University of Cambridge have been announced by Peter Kyle MP, the Secretary of State for Science, Innovation and Technology, supported by £160 million in funding.

The UK Hub for Quantum Enabled Position, Navigation and Timing (QEPNT), led by the University of Glasgow, will develop quantum technologies which will be key for national security and critical infrastructure and sectors such as aerospace, connected and autonomous vehicles (CAVs), finance, maritime and agriculture. Dr Luca Sapienza from the Department of Engineering is part of the QEPNT team.

QCI3: Hub for Quantum Computing via Integrated and Interconnected Implementations, led by the University of Oxford, aims to develop the technologies needed for the UK to play a key role in the development of quantum computers, a market estimated to be worth $1.3 trillion by 2030. Professor Chander Velu from the Institute for Manufacturing is part of the QCI3 team.

The Integrated Quantum Networks (IQN) Quantum Technology Research Hub, led by Heriot-Watt University, will undertake research towards the ultimate goal of a 'quantum internet', globally interlinked quantum networks connecting multiple quantum computers to produce enormous computational power. Professor Richard Penty, Adrian Wonfor and Dr Qixiang Cheng from the Department of Engineering are part of the IQN team.

The other hub involving the University is Q-BIOMED, led by Cambridge and UCL. It will exploit advances in quantum sensors capable of detecting cells and molecules, potentially orders of magnitude more sensitively than traditional diagnostic tests.

Read the full article at:
www.eng.cam.ac.uk/quantum-future

OPINION

Professor Matthew Juniper on his role as a commissioner for the Institute for Government

Since March 2023, Professor Matthew Juniper has been a commissioner for the Institute for Government's (IfG) Commission on the Centre of Government. 'Power with purpose' is the final report. The report finds that No.10 Downing Street, the Cabinet Office and the Treasury are not equipped to meet the challenges facing the United Kingdom in the 21st century.

The Commission's conclusions draw on a year of interviews with former prime ministers, leading scientists, senior civil servants, local government, the private sector, and charities.

We spoke to Matthew about his role as a commissioner for the IfG.

What is the IfG and what does it do?

The IfG is an independent think tank set up in 2008 by the Sainsburys' charitable foundation. It explores how government works and how it could work better.

How did the brief to examine the centre of government come about?

The Historian Anthony Seldon approached the IfG, in 2023, about a commission focused on how the centre of government can work better. He has written biographies of every prime minister since John Major and was particularly motivated by Tony Blair's experience in 1997: Labour had been out of power for 18 years and did not have any institutional memory in government. Expecting the UK to be in a similar position in 2024, part of the brief was to help the next government hit the ground running.

Who did you interview?

We had input from around 40 people, ranging from three ex-prime ministers, two ex-chancellors, many senior civil servants, business leaders, political advisers, local politicians, academics, and senior civil servants from overseas. As is customary, we could report what was said but not who said it, so they were all candid about the problems at the centre, possible solutions, and what would be daft.

What are the IfG's recommendations?

Five of the seven recommendations are about the civil service structure that surrounds the Prime Minister and the cabinet. I think, however, that the most interesting recommendations are the other two: the first ("agree priorities at the start of a parliament") and the last ("reflect these priorities in a shared strategy, budget, and performance management process owned collectively at the centre of government").

The first recommendation was inspired by the coalition government from 2010 to 2015, which had to write a programme for government *post*-election rather than follow manifesto pledges made *pre*-election. Whatever interviewees thought of the policies of the coalition, there was broad agreement that they were implemented effectively because the centre had set a clear achievable direction early and there was a high cost to both parties if they deviated from it.

I think it would be beneficial to accept that a new government will have to tweak their manifesto pledges once they come to power, because these pledges were created by under-resourced data-poor political teams while in opposition, and they would benefit from revision by well-resourced data-rich civil servants when a party starts in government.

The last recommendation is a swipe at the Treasury's power to distort a government's strategy by prioritising fiscal policy (balancing the books) over economic policy (investing for growth), and the misalignment between the Government's overall strategy and the spending decisions made by the Treasury. All interviewees agreed that balancing the books is important, but that chronic neglect of growth has contributed to poor productivity growth in the UK for decades. People involved in the project who had worked in the Treasury made this point particularly persuasively, as did Gordon Brown at the report's launch, and the report itself devotes several pages to it.

Read the full interview, download the final report and watch a video explaining the key findings at:
www.eng.cam.ac.uk/commissionerifg

→ Student Kate Lucas is presented with the Volunteering Award by University of Cambridge Vice-Chancellor Professor Deborah Prentice

Credit: Cambridge Hub

Kate Lucas – Vice-Chancellor's Social Impact Award winner

Third-year Manufacturing Engineering Tripos (MET) student Kate Lucas has been announced as a winner of the Vice-Chancellor's Social Impact Awards 2024.

Kate, the outgoing Co-President of Cambridge University Robotics (CUR) student society, was presented with the Volunteering Award recently at a ceremony organised by Cambridge Hub and sponsored by the Vice-Chancellor's Office.

The Vice-Chancellor Professor Deborah Prentice hosted the ceremony, which saw 15 students recognised with awards. The Awards recognise and celebrate exceptional achievement in contributing to society. Kate was honoured for her "dedication to increasing diversity in engineering".

In addition to her role in CUR and organisation of Unibots UK 2023 and 2024 (an inter-university competition for undergraduates that is hosted annually by CUR in the Department of Engineering), Kate mentors Year 13 students through platforms such as Zero Gravity. She is also an active ambassador for Homerton Changemakers.

"I think one of the activities that led to this award was the after-school sessions I ran in collaboration with Cambridge Science Centre with a group of seven-to-11-year-old pupils," said Kate, who studies at the Institute for Manufacturing (IfM), part of the Department of Engineering. "Along with Henry Wall (a third-year engineering student), we designed and delivered activities to teach kids about robotics."

Kate added: "My big aim for the Unibots UK 2024 event, run in collaboration with students from Heriot-Watt University, was to create a community of people interested in robotics, particularly those from universities that may not have access to the same level of facilities that we do here in Cambridge e.g. the Dyson Centre for Engineering Design. It was the biggest event of its kind, with more than 100 students attending from England, Scotland and Wales.

"I have been involved with mentoring students through a variety of different channels but I would like to highlight the Apply: Cambridge scheme, where you work with six Year 13 students from disadvantaged backgrounds, and Zero Gravity, which is an online mentoring platform also aimed at disadvantaged students."

What have you gained, experience-wise, from being Co-President of CUR?

"So many things! It is difficult to list them all, but certainly time management skills. I have also had the opportunity to meet a great range of people, from new society members and staff in the Department to people from outside of the University.

"I think people underestimate the range of activities that you can be involved in as a student society president. I have done everything from pitching to sponsors for funding and carrying out laser cutting of trophies to navigating the Department's room booking system and even attending awards ceremonies on behalf of the society."

> One of the activities that led to this award was the after-school sessions I ran in collaboration with Cambridge Science Centre. We designed and delivered activities to teach kids about robotics.
>
> MET student Kate Lucas

→ www.curobotics.co.uk

→ The reconstructed historic Venn bowling machine in action. CENTRE: Dr John Venn, the inventor

Credit: Adam Page. CENTRE: by permission of the Master and Fellows of Gonville & Caius College, Cambridge

Engineers bring historic bowling machine back to life

Engineers have reconstructed a historic bowling machine that bowled out players from the Australian cricket team during a visit to the city more than 100 years ago.

Using patent illustrations and an old photograph discovered online, the team brought the 7ft contraption to life using materials that would have been available when Dr John Venn – who first described what are now known as Venn Diagrams, and was also President of Gonville & Caius College – created it in the early 1900s, and which bested the Australian cricketers in 1909.

The Venn bowling machine propels the cricket ball using a throwing arm powered by elastic rope. But what makes its design special is the ingenuity used to put spin on the ball – when the arm travels it pulls a string, which turns a spindle and a bobbin, which in turn spins the ball holder and the ball.

Hugh Hunt, Professor of Engineering Dynamics and Vibration – who previously led teams of investigators on the Channel 4 shows *Dambusters: Building the Bouncing Bomb*, and *Attack of the Zeppelins*, and who has a research interest in "spinning things that fly" – set the Department of Engineering the challenge of recreating the machine, which will be used at events and open days, and aims to capture the imagination of young people considering a career in maths and engineering.

Professor Hunt said: "It's a great story, and an ingenious device, and at the time would have been in a lot of newspapers, but now it's not really remembered outside the cricket world. Most people learn about Venn Diagrams at school, but not many know about John Venn's quirky side – that he invented a bowling machine using wood and string and maths, which bowled out members of the Australian cricket team more than 100 years ago. So the idea behind the project was to recreate a bit of history, and to show how much fun you can have with maths."

However, all the Cambridge engineers had to work from was a black and white photograph of the machine, and a patent application from the time.

Thomas Glenday, Head of Design and Technical Services, said: "The patent is around the intellectual property, rather than the technical detail, so we didn't have a set of engineering drawings to work with. It meant we had to sketch it out for ourselves, figure out how the machine was actually going to work, and how it replicates the skill and speed of a spin bowler.

"The spin has been the key piece, and probably the most complicated part of the design. It's thinking about the different forces that are acting on the ball simultaneously, and that transition of energy – it makes one hell of a diagram!"

But beyond the technical challenges, an important consideration for the team has been making sure the reconstructed machine is historically authentic.

"It's a fun project, but we definitely wanted it to look the part," said Thomas. "We used high-quality hardwood, and really not much is made from wood these days, particularly for a device like this. But back then it was where the skillset was – people were used to working with wood, which has natural faults, which moves, which is not necessarily square. Today it would have been carbon fibre, and you'd be fabricating the pieces with a 3D printer."

Written by Stephen Bevan

> The spin has been the key piece, and probably the most complicated part of the design. It's thinking about the different forces that are acting on the ball simultaneously, and that transition of energy – it makes one hell of a diagram!
>
> Thomas Glenday

Watch a demo of the machine:
youtu.be/wuYkRoVaP7s

→ RIGHT: Cambridge researcher and cricketer Dr Darshil Shah

Credit: [LEFT] u_g5kzowan0q from Pixabay

Batting a path to sustainable cricket innovation

A new project involving Cambridge researchers aims to challenge existing "wasteful" practices in the design and production of cricket gear – and help preserve and grow the UK cottage industry supporting it.

Funded by the Arts and Humanities Research Council (AHRC), and with the input and support of industry partners and social enterprise, the Design Accelerator project seeks to align the UK's second-largest sport with net zero considerations by integrating circular design principles – reuse; repair; remanufacture; and recycle – into the product design and manufacture of cricket gear.

Led by the University for the Creative Arts (UCA) in collaboration with Dr Darshil Shah, Associate Professor in Materials and Design at Cambridge, the project involves research into locally produced biomaterials, recycled materials and reused components for batting pads.

Batting pads are multi-component and multi-material and typically contain a mix of polyurethane, paperboard, cane, polyester mesh, high-density foam, thermoformed polystyrene, polyester lining and wadding (made of 50% cotton and 50% polyester). These materials, parts and components typically end up in landfill at the end of the product's lifecycle and most are made from non-renewable sources.

The total carbon footprint of a pair of batting pads is equivalent to 2.60 CO_2 eq. Kg/functional unit[1] – similar to driving a distance of 10km – with, for example, 351,000 pairs of pads (552 tonnes) coming to the end of their first use life each year[2]. This is why sustainable alternatives are being sought in the form of biomaterials that are wholly or partially derived from plants, trees, or animals, as well as exploration of design changes to extend the useful life of the product.

The hunt for alternative sustainable materials to develop, produce and test circular cricket batting pad prototypes is being led by Dr Shah from the Centre for Natural Material Innovation (CNMI) – a cross-disciplinary centre based in the Department of Architecture. Dr Shah also teaches at the Department of Engineering, where he supervises fourth-year MEng Engineering Tripos individual projects.

A keen cricketer and a former member of Thailand's under-19 national cricket team, Dr Shah and his colleagues will use sustainable alternative materials identified in recent Cambridge research (e.g. synthetic chamois leathers for linings; waste fibres from banana leaf for fluffy fillings; and waste plastic materials for cane strips in pads) to develop four batting pad prototypes.

Dr Shah said: "Cricket is the most kit-intensive sport in the world. The production of cricket gear is characterised by wasteful e.g. linear and non-circular product lifecycles and currently features little repair and refurbishment, and limited reuse[3], with much of the kit ending up in landfill. The manufacture of cricket gear is predominantly carried out in South Asia, thus increasing the embedded carbon of imported cricket gear.

"Our research has shown that there is huge potential for reusing different parts of these multi-material products, with a number of sustainable alternative materials to explore, many of which are plant-derived, and could be suitable for high-impact, resistant, rigid components such as batting pads.

"Design and material innovation of cricket gear is critical if the sport is to improve its reach and sustainability. As an established cottage industry, there remain conservative attitudes towards innovation within cricket that have contributed to the preservation of traditional materials.

"These multi-component products are hand produced. For example, it can take a worker one day to make two pairs of cricket gloves. But this time-intensive level of craftsmanship in the UK is under increasing threat, with the heritage craft of cricket ball making now extinct in the UK. Through this Design Accelerator project, we hope to preserve the skillset of stitching/sewing cricket gear here in the UK by training up a workforce for the making, repair and refurbishment of prototype batting pads."

—

[1] Dr Lilian Sanchez Moreno and Professor Martin Charter. *Final Report – Streamlined Life Cycle Assessment: Pair of Cricket Batting Pads*. The Centre for Sustainable Design, 2023.

[2] Professor Martin Charter and Tom Clark. *Final Report – Sustainability, Cricket Gear, Clothing and Apparel: Report on Cricket Gear*. The Centre for Sustainable Design, 2022.

[3] Joanna Czutkowna and Martin Charter. *Final Report – 3Rs: Reuse, Repair, Refurbishment and Resale Report on Cricket Gear*. The Centre for Sustainable Design, 2023.

Read the full article at:
www.eng.cam.ac.uk/sustainable-cricket

→ From left, Mastercard Foundation Scholars Chibuzor Ndubisi, Itumeleng Sebata and Godbless James

Credit: Charlotte Hester

Meet Africa's next generation of transformative leaders

"It's been eye-opening to see the world from so many different angles. Cambridge creates a dynamic learning environment where everyone has something valuable to contribute," says Mastercard Foundation Scholar Itumeleng Sebata.

Itumeleng is one of six Scholars from Africa who has recently completed an engineering-related Master's degree at Cambridge. Itumeleng and her peers are among a wider cohort of 46 Scholars, drawn from 18 different African countries, who studied a range of subjects during the 2023-24 academic year as part of the Mastercard Foundation Scholars Program.

This fully funded opportunity helps to develop transformative leadership skills and aims to contribute to climate resilience and sustainable futures in Africa.

Itumeleng Sebata

Itumeleng, from Zimbabwe, has a background in electronic engineering and a passion for solving real-world problems. Itumeleng was drawn to the MPhil in Industrial Systems, Manufacture and Management (ISMM) because of the company visits, projects and hands-on sessions it offers.

"Through ISMM, I've gained insights into the importance of effective collaboration among people, facilities and processes in order to improve business efficiency," she said.

"My goal is to contribute to the advancement of industrial practices and continuous improvement back home (e.g. in the food industry or cement industry) by implementing new technologies and scaling up operations, tailored to our local context."

Godbless James

Godbless, from Nigeria, has a background in technology consultancy, computer science and informatics. Godbless was drawn to the MPhil in Machine Learning and Machine Intelligence because of his desire to develop intelligent systems that can address practical challenges and contribute to societal improvement.

"Having witnessed the destructive effects of climate change in my riverine community, and drawing from my experience in machine learning, I envisage, for example, using AI to optimise carbon capture and storage systems to combat carbon emissions," he said. "This would address the excessive heat experienced in communities around the Niger Delta, caused by gas flaring and oil spills."

He added: "Additionally, given the busy and persistent traffic situation in a city like Lagos, where I lived, I could also explore the development of intelligent transportation systems to enhance urban mobility. This would involve leveraging computer vision and data analytics for safer and more efficient traffic management."

Chibuzor Ndubisi

Chibuzor, from Nigeria, was drawn to the MPhil in Engineering for Sustainable Development (ESD) because he aims to commercialise breakthrough energy innovations for African communities, upscale climate change mitigation and adaptation efforts, and transform industries dependent on energy – each with a sustainability-focused and human-centred philosophy.

"I grew up watching my parents struggle unduly to ensure that we had power in our home," he said. "I'd seen businesses crumble, plans fail, and dreams die because of Nigeria's energy crisis. I'd read and heard reports of children developing chronic illnesses due to breathing in fumes from generators."

He added: "My mission is to address what I've termed Africa's 'energy paradox': transitioning to clean energy technologies, while expanding energy access on the continent."

Read the full article at:
www.eng.cam.ac.uk/mastercard-scholars-2024

Watch the video interviews:
youtu.be/ej_dFXjbUoE

ALUMNI UPDATE

Meet Tom Smith – off-grid energy and water access entrepreneur

Tom Smith co-founded Thermofluidics with prize money from The Royal Institution and The Sunday Times whilst he was a PhD research student at the Department of Engineering (2001-2005). Driven by a lifelong passion to make sustainable energy and water services available to all, he's now the inventor of numerous energy and water technologies and the Chief Technical Officer of Thermofluidics and its subsidiaries Impact Pumps and Blue Tap. We caught up with Tom to find out more.

"Whilst I was a Physics undergraduate at Imperial College, I started to think about how thermally-driven fluid oscillations could be harnessed to pump fluids or heat without moving parts and how this could enable affordable water pumping and refrigeration. I raised my first research grant from the California Energy Commission in 1999 and applied for a studentship at the Department of Engineering. Soon after, I found myself with one of the world's greatest pools of resources at my fingertips.

"Using analogies between electronic and thermo-fluid components, I created a simple variable-frequency two-phase thermofluidic oscillator called the NIFTE (Non-Inertive-Feedback Thermofluidic Engine) and later co-founded Thermofluidics to develop it commercially.

"Our first big break came with £5 million from the Wellcome Trust to develop a solar thermally-powered irrigation pump. By 2016, we had prototypes running well at trial sites in India and Bangladesh. But heat engines are fundamentally surface-level devices, and most farmers don't have access to near-surface water (fewer than 10% in sub-Saharan Africa). We needed a solution to reach groundwater.

"Inspiration came from an 18th century water-powered technology called a 'Hydram', which uses the Joukowski (water hammer) effect to raise water from rivers and streams without sliding seals or mechanisms. Individual examples have operated for more than 100 years, but their use declined in the early 20th century with the arrival of more versatile diesel and electric pumps.

"We re-engineered the Hydram as a borehole pump, powered by a circulating flow from surface level. The resulting 'Double-Acting Hydraulic Ram' (DAHR) extends the reach of most surface pumps to over 50m (within reach of over 90% of sub-Saharan Africans). Shockwaves replace pistons and impellers, resulting in a solution which is durable to sand, silt, corrosion and air, whilst exhibiting hydraulic efficiencies currently around 92%.

"We installed our first field-ready DAHR on a subsistence smallholding in Kenya in 2018. The farmer fell to his knees and described a lifetime hauling heavy buckets out of wells day-in, day-out, since childhood. It was a very powerful moment: the feeling of a long-held need for purpose suddenly becoming fulfilled. The DAHR entered production in Birmingham and Shanghai in 2021 and is now sold as the 'FlexExtend – Suction Lift Extender (SLX)' under the brand 'Impact Pumps'. Across scores of units installed around the world, none have failed to date.

"In the context of rapidly declining photovoltaic (PV) prices, NIFTE couldn't compete in solar-powered applications in the end. So, we developed the 'SolarPlex': a PV-centrifugal surface pump with a novel integrated approach to PV-powered motor commutation. This approach enables high efficiency and reliability without compromising affordability. It involves miniaturising and integrating components into the motor heatsink whilst using the intrinsic inductance of the motor armature for voltage regulation. The combined SolarPlex-Extend exploits a unique characteristic of hydrams that permits it to operate around its 'Best Efficiency Point' over a wide range of independently varying water depths and solar power levels, consistent with real-world use.

"Embracing power electronics has opened many doors. As Blue Tap trials a PV-chlorinator that converts trace chloride in groundwater to free chlorine without chemical additives, Thermofluidics is turning its attention to transferring our novel inverter and remote control capabilities to heat pumps in the UK.

"Ultimately, whether on-grid or off-grid, addressing energy and water services as a systemic whole opens many opportunities, which can improve access to both."

Read the full article and watch Tom's TEDx talk at:
www.eng.cam.ac.uk/tomsmith

Credit: Wolfilser – stock.adobe.com

Study to explore if circular economy can meet needs of UK's buildings

Cambridge engineers will join a new £6 million project exploring the extent to which the circular economy could meet the UK's building needs – using zero new material extractions, with zero emissions and zero waste.

BuildZero, led by the University of Sheffield, and funded by the EPSRC, will be carried out in partnership with the Universities of Cambridge, Manchester and Bath, Cardiff University, and industrial collaborators.

The five-year project will develop a detailed vision of more sustainable building practices, considering the options for developing methods for building without extracting new resources, as well as eliminating waste and reducing carbon emissions from material extraction and production.

BuildZero will assess the extent to which the vision for a circular economy is achievable at regional and national level and will provide a platform for demonstrating these solutions at scale.

At Cambridge, Professor Jonathan Cullen and Dr André Cabrera Serrenho will be developing the most complete and open characterisation of the existing building stock in the UK, including physical features, ownership status and patterns of use.

"This will allow us to anticipate how to best serve the future building needs and space solutions with minimal greenhouse gas emissions and resource use," said Dr Cabrera Serrenho, Assistant Professor in Engineering, Environment and Sustainable Development.

Buildings and infrastructure are responsible for more than 40% of the UK's carbon emissions, produce more than 60% of the UK's waste, and consume approximately 50% of all extracted materials globally. So, to decarbonise construction, significant changes are required.

The circular economy is a widely recognised opportunity to reduce both resource consumption and carbon emissions. In a circular economy, materials are kept at the highest value possible, for example retrofitting buildings and repurposing buildings to extend their lifespans.

In the past, circular economy examples for the building sector have mostly focused on case studies of individual buildings, or recycling of individual materials, which misses the opportunity for making changes to the wider system. BuildZero aims to present a larger-scale, systems-level approach to making changes in the construction sector.

The research will use methods from across several disciplines, including architecture, structural engineering, materials science and social sciences to understand the existing building stock, resource and waste flows, social attitudes and economics surrounding potential circular economy business models for the construction sector.

The research programme will culminate in a range of demonstrator projects, interactive tools, detailed strategies, and ultimately a series of pathways to achieve the BuildZero vision of a UK building stock with zero new raw material extraction, zero emissions and zero waste.

Dr Cabrera Serrenho added: "We are excited to be part of BuildZero, and to contribute to revealing novel opportunities to enhance our building stock with minimal emissions and material inputs. At Cambridge, we will improve our understanding of the physical features of our current building stock and develop tools to assist decision-making for various stakeholders."

Read the full article at:
www.eng.cam.ac.uk/uk-buildings

Credit: Charlotte Hester

Students' robotic fish hooks an honourable mention at global robot design competition

↑ Pictured with their 'Robot Fish', from left, Clare Heinbaugh, Sedinam Simpson and Akshay Choudhry

Three students studying for an MPhil in Machine Learning and Machine Intelligence were challenged to create a biologically inspired robot prototype for under $50. The result? A robotic fish with plenty of potential.

Sedinam Simpson, Clare Heinbaugh and Akshay Choudhry created the swimming robot – an extension of their robotics coursework project – in six weeks. Made from foam, duct tape and weighed down with screws to ensure partial submersion in water, the robot has a microprocessor for a 'brain', powered by a battery, and a light sensor that helps to control the speed of the servo motor. The more light there is the faster the servo motor drives the fish tail back and forth.

'Robot Fish', which is WiFi-enabled to allow experiments to be run remotely via a smartphone or laptop, received an honourable mention at the Soft Robotics on a Budget Challenge, hosted by the Democratization of Soft Robotics through Embodied Intelligence workshop.

Teams from around the world competed to come up with a simple, low-cost robot prototype that offers a solution to a specific real-life robotics problem.

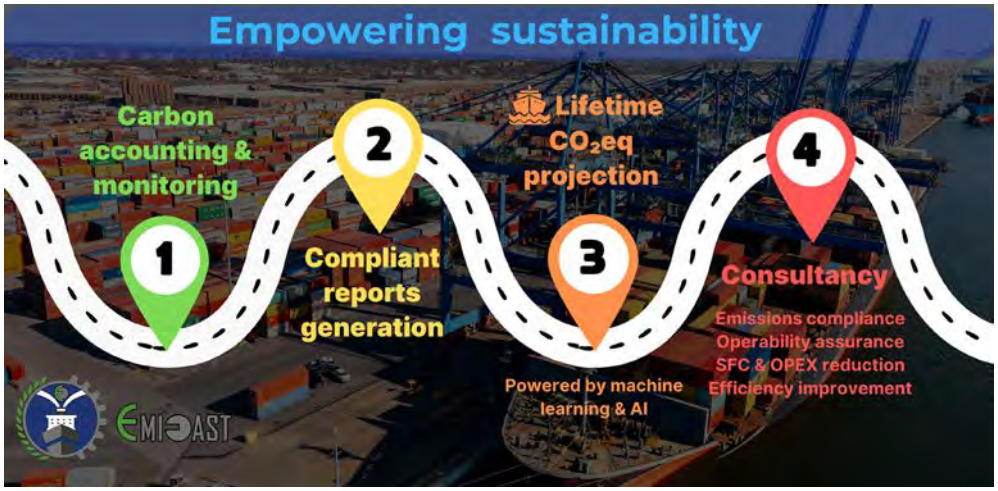
Sedinam, Clare and Akshay say their Robot Fish has the potential to be used for underwater surveillance or excavation thanks to the inclusion of a fish eye that could, with further development, be replaced with a camera. The eye allows for tracking to create positional graphs.

"We were inspired to build Robot Fish as it was a chance to apply the theory we have been learning in the MPhil in a real project," said Clare. "There are a lot of interesting hydrodynamic questions to be answered with robotic fish such as understanding how robotic actuators work in water."

Sedinam added: "We enjoyed having fun during the process and the journey of creating something. Even a simple idea, like constructing a robotic fish in water, can be quite complicated to implement, especially with a physical product, which none of us had much experience with beforehand. We found the iterative process challenging. Some days we would spend hours in the lab and 'fail', but even in the failure we learnt what not to do the next time. On other days, things would go smoothly."

> We were inspired to build Robot Fish as it was a chance to apply the theory we have been learning in the MPhil in a real project.
>
> MPhil student Clare Heinbaugh

Watch Robot Fish 'swim':
youtu.be/M3gEFSF0GXY
www.mlmi.eng.cam.ac.uk



EMICAST: Supporting a sustainable maritime future

With the climate impact of shipping increasingly under the spotlight – accounting for around 3% of greenhouse gas (GHG) emissions worldwide – researchers from Cambridge and Singapore have launched a start-up that aims to visualise shipping emissions and help improve the design of future ships.

Using novel modelling techniques and data, EMICAST aims to empower maritime stakeholders such as shipowners and operators to optimise both operational efficiency and profitability, while adhering to regulatory standards – streamlining emissions compliance in the process.

The spin-out has been founded by Dr Li Chin Law from the Cambridge Centre for Advanced Research and Education (CARES) and Dr Savvas Gkantonas from Cambridge's Department of Engineering, with Professor Epaminondas Mastorakos acting as Scientific Adviser.

It comes at a time when the International Maritime Organization (IMO) has announced its aims for a sectoral target of net zero greenhouse gas emissions from international shipping to be reached by or around 2050.

"This can be achieved in various ways, such as by improving ship design and combustion systems; transitioning away from fossil fuels; optimising energy efficiency of ships; capturing CO_2 from the exhaust; and investing more in innovative solutions," said Dr Law.

EMICAST has been created with the primary goal of providing comprehensive services encompassing carbon accounting, reporting, and emissions forecasting to accurately quantify GHG intensities and the associated potential penalties.

"What we are aiming to offer with EMICAST is advanced visualisation of ship emissions through rigorous carbon accounting and forecasting techniques powered by machine learning algorithms," said Dr Law. "Through the deep knowledge of alternative low-carbon fuels and novel propulsion systems, EMICAST can also help with the design of future ships."

The initiative behind EMICAST has its roots in scientifically published models of alternative fuels and the impact of these fuels on ship propulsion systems. With EMICAST, timely low-carbon solutions can be tailored to individual ships, ensuring emissions compliance while safeguarding operators' profitability.

Professor Mastorakos said: "Maritime decarbonisation is not easy. Many solutions have been proposed such as hydrogen, ammonia, methanol, e-fuels, biofuels, and on-board carbon capture, and each has its own strengths, weaknesses, and technological, financial and supply chain bottlenecks.

"Over many years, the research at Cambridge CARES on many of these technologies has resulted in better understanding of the underlying concepts, such as lifecycle analysis; how ammonia burns in an engine; and how carbon capture can be implemented with on-board blue hydrogen production.

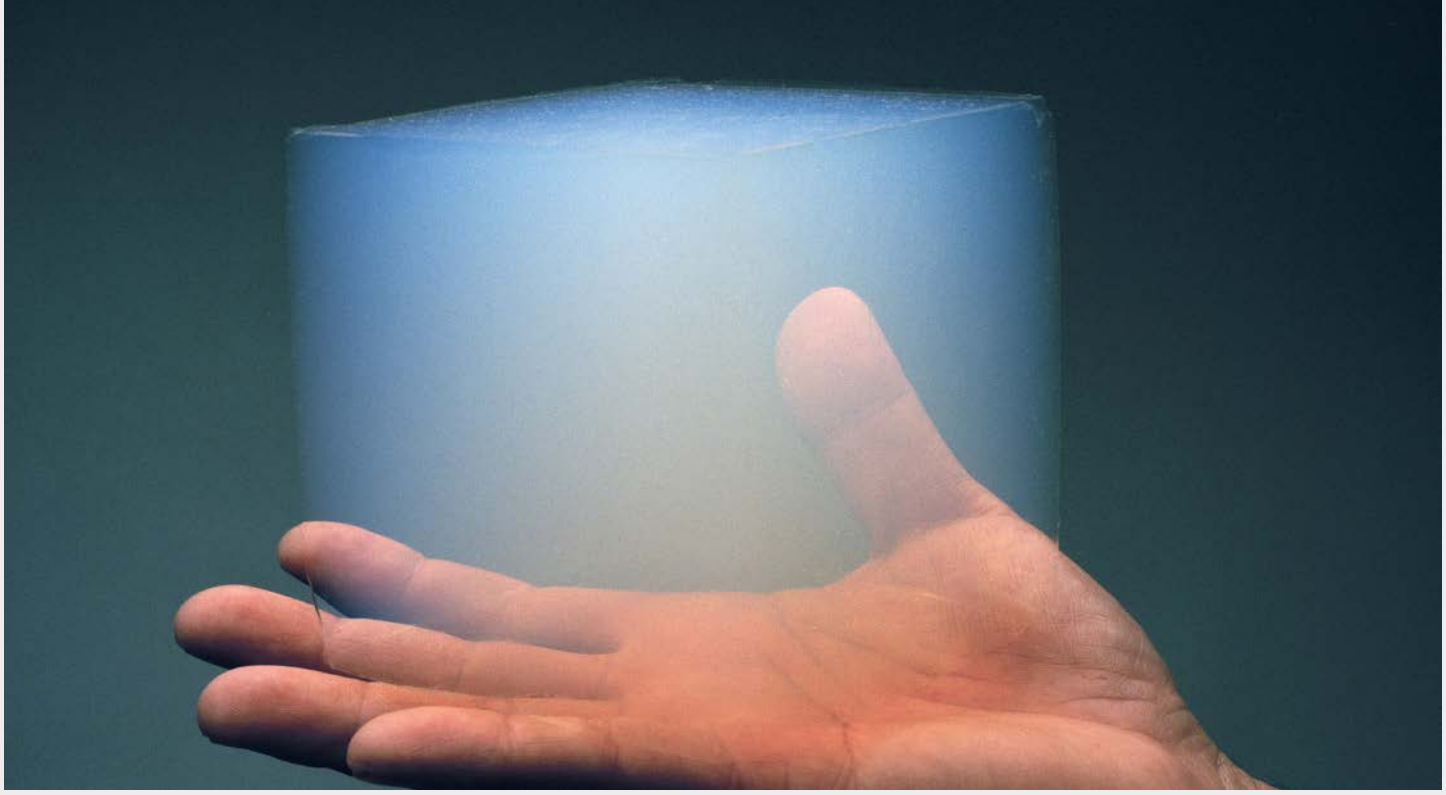
"EMICAST has been founded with the aim of helping the industry pick the most suitable decarbonisation solution based on their particular routes, ships and propulsion systems. Data analytics and modelling are used to develop quantitative strategies for minimising emissions."

Dr Gkantonas said: "Big data acquisition and analytics are crucial for shipping and they are supported by many ongoing developments on automated tracking and on-board sensing systems. Our aim is to leverage big data and novel modelling techniques put forward at Cambridge CARES to support new low-carbon ship design but also to monitor, forecast and optimise ship and engine operation."

Dr Law added: "A thorough understanding of various solutions, from thermodynamics to technological intricacies, ensures the design of a low-carbon ship that is truly efficient."

This research is supported by the National Research Foundation, Prime Minister's Office, Singapore under its Campus for Research Excellence and Technological Enterprise (CREATE) programme.

emi-cast.com
www.cares.cam.ac.uk



Credit: NASA/JPL-Caltech

↑ Silica aerogel

Sensors made from ‘frozen smoke’ can detect toxic formaldehyde in homes and offices

Researchers have developed a sensor made from ‘frozen smoke’ that uses artificial intelligence techniques to detect formaldehyde in real time at concentrations as low as eight parts per billion, far beyond the sensitivity of most indoor air quality sensors.

The researchers developed sensors made from highly porous materials known as aerogels. By precisely engineering the shape of the holes in the aerogels, the sensors were able to detect the fingerprint of formaldehyde, a common indoor air pollutant, at room temperature.

The proof-of-concept sensors, which require minimal power, could be adapted to detect a wide range of hazardous gases, and could also be miniaturised for wearable and healthcare applications. The results are reported in the journal *Science Advances*.

Volatile organic compounds (VOCs) are a major source of indoor air pollution, causing watery eyes, burning in the eyes and throat, and difficulty breathing at elevated levels. High concentrations can trigger attacks in people with asthma, and prolonged exposure may cause certain cancers.

Formaldehyde is a common VOC and is emitted by household items including pressed wood products (such as MDF), wallpapers and paints, and some synthetic fabrics. For the most part, the levels of formaldehyde emitted by these items are low, but levels can build up over time, especially in garages where paints and other formaldehyde-emitting products are more likely to be stored.

According to a 2019 report from the campaign group Clean Air Day, a fifth of households in the UK showed notable concentrations of formaldehyde, with 13% of residences surpassing the recommended limit set by the World Health Organization (WHO).

“VOCs such as formaldehyde can lead to serious health problems with prolonged exposure even at low concentrations, but current sensors do not have the sensitivity or selectivity to distinguish between VOCs that have different impacts on health,” said Professor Tawfique Hasan from the Cambridge Graphene Centre, who led the research.

“We wanted to develop a sensor that is small and does not use much power, but can selectively detect formaldehyde at low concentrations,” said PhD student Zhuo Chen, the paper’s first author.

The researchers based their sensors on aerogels: ultra-light materials sometimes referred to as ‘liquid smoke’, since they are more than 99% air by volume. The open structure of aerogels allows gases to easily move in and out. By precisely engineering the shape, or morphology, of the holes, the aerogels can act as highly effective sensors.

Working with colleagues at Warwick University, the Cambridge researchers optimised the composition and structure of the aerogels to increase their sensitivity to formaldehyde, making them into filaments about three times the width of a human hair. The researchers 3D printed lines of a paste made from graphene, a two-dimensional form of carbon, and then freeze-dried the graphene paste to form the holes in the final aerogel structure. The aerogels also incorporate tiny semiconductors known as quantum dots.

The sensors they developed were able to detect formaldehyde at concentrations as low as eight parts per billion, which is 0.4% of the level deemed safe in UK workplaces. The sensors also work at room temperature, consuming very low power.

“By building a sensor that is able to detect specific VOCs at very low concentrations in real time, it can give home and business owners a more accurate picture of air quality and any potential health risks,” said Professor Hasan.

Written by Sarah Collins

Open access paper:
www.eng.cam.ac.uk/formaldehyde

Harald Haas appointed to the Van Eck Professorship of Engineering

Professor Harald Haas pioneered 'LiFi' (Light Fidelity) – the transmission of data through light modulation at potentially much higher data rates than is possible with WiFi or 5G. He coined the term LiFi during his talk at the TED Talk Global 2011 "Wireless Data from Every Light Bulb", during which he highlighted the technology that is able to transmit high-definition videos at high speed with only the use of overhead lighting. The talk has been watched more than 2.7 million times.

Professor Haas is the initiator, co-founder and Chief Scientific Officer of pureLiFi Ltd as well as the Director of the LiFi Research and Development Centre.

His most recent research interests are in combining physics, communication theory and artificial intelligence to develop new wireless technologies and systems for secure, high-speed and net zero communication networks.

He leads one of three new Telecoms Hubs on 'Network of Networks' in the UK, TITAN, which is a consortium of 16 universities and four UK research institutions. He has co-authored more than 650 conference and journal papers with more than 50,000 citations and holds 45 patents, and has been listed as a highly cited researcher by Clarivate/Web of Science since 2017.

Read the full article at:
www.eng.cam.ac.uk/harald-haas

The Van Eck chair in Engineering

The Van Eck chair in Engineering was created thanks to a legacy from Mr Fred van Eck. The chair sits within the field of advanced science and technology, with an emphasis on high-speed communications. It was previously held by Professor Ian White, until he left to become Vice-Chancellor of the University of Bath.

Steven Barrett appointed Regius Professor of Engineering

An expert on the environmental impacts of aviation, Professor Steven Barrett joins the University of Cambridge from the Massachusetts Institute of Technology (MIT), where he was head of the Department of Aeronautics and Astronautics.

Professor Barrett's appointment marks his return to Cambridge, where he was an undergraduate at Pembroke College, and received his PhD. He was a Lecturer in the Department of Engineering from 2008 until 2010, when he joined the faculty at MIT.

The Regius Professorships are royal academic titles created by the monarch. The Regius Professorship in Engineering was announced in 2011, in honour of the late HRH Prince Philip, Duke of Edinburgh's 35 years as Chancellor of the University.

"This is an exciting time to work on sustainable aviation, and Cambridge, as well as the UK more generally, is a wonderful platform to advance that," said Professor Barrett. "Cambridge's multidisciplinary Department of Engineering, as well as the platform that the Regius Professorship provides, makes this a great opportunity. I've learned a lot at MIT, but I'd always hoped to come back to Cambridge at some point."

Much of his research focuses on the elimination of contrails, line-shaped clouds produced by aircraft engine exhaust in cold and humid conditions. Contrails cause half of all aviation-related global warming – more than the entirety of the UK economy. Professor Barrett uses a combination of satellite observation and machine learning techniques to help determine whether avoiding certain regions of airspace could reduce or eliminate contrail formation.

Read the full article at:
www.eng.cam.ac.uk/steven-barrett

Operators unite in electric heavy goods vehicles trial

Electric heavy goods vehicles (HGVs) are to be trialled across the UK in a new programme to help freight operators decarbonise their fleet.

Called Project JOLT – standing for Joint Operator Logistics Trial – the programme is led by The Centre for Sustainable Road Freight (SRF) and involves partners including John Lewis Partnership, Volvo Trucks UK, and Flexible Power Systems, a software company specialising in fleet management optimisation software for electric vehicles.

The trial will pool operations and technical data from a fleet of rigid and articulated eHGVs being used across a wide range of Third-Party Logistics (3PL), retailer and manufacturer use cases.

Project JOLT will provide shared access to a fleet of electric vehicles and mobile chargers, which can be used by each partner for the purpose of carrying out a pre-agreed sequence of partner trials. High-resolution operational data will be collected during each trial period and then analysed, anonymised, and shared with all partners as part of a managed collective learning process. All shared data will be subject to the provisions of a data confidentiality agreement, which will be agreed between all partners before the work starts.

The objective is to develop the knowledge and models needed to de-risk electric freight operations and inform investment decisions. The participating fleet operators will share their learning experiences in a pre-competitive environment to develop a clear understanding of how electric vehicles and charging infrastructure can be deployed most effectively to serve their business needs.

The trial is open to all HGV operators becoming involved by accessing a shared vehicle fleet supplied by Original Equipment Manufacturers (OEMs) or sharing data from their own vehicles.

The electrification of the UK's commercial fleets needs to happen urgently. Freight is hugely important; it contributed £13.6 billion to the economy in 2022*, and 98% of our food and agricultural products are carried by road, mostly on HGVs. However, HGVs also account for 20% of CO_2 emissions from domestic transport.

Ensuring a smooth transition to electrification is a multi-faceted and onerous challenge: data-driven insights are key to ensuring the confidence for companies involved in logistics to begin or continue their journey towards net zero.

SRF was founded to help industry and government minimise carbon emissions from the road freight sector and is a collaboration between the University of Cambridge, Heriot-Watt University, the University of Westminster, and industry and government partners.

David Cebon, Professor of Mechanical Engineering at the University of Cambridge and Director of SRF, established Project JOLT. He said: "The urgency of the climate crisis is driving adoption of electric HGVs at a rate that few in the industry would have expected five years ago.

"Operators are purchasing and running these vehicles today in fleets of all sizes. But there's still a long way to go to understand how whole fleets and industries can transition to electric HGVs in a technically feasible way."

The JOLT partners will pool data and learning from their experiences with eHGVs in retail, delivery, and manufacturing operations to help develop transition plans for their own businesses and for the wider logistics industry.

Specialists at Cambridge and Heriot-Watt University will analyse and model data including vehicle and charger performance, operational efficiency, and costs, across as many industry uses as possible.

Professor Philip Greening is an expert in sustainable transport and logistics at Heriot-Watt University and co-director of SRF. He said: "A key feature of this project is understanding how the different range and load capabilities of electric HGVs – as well as downtime for charging – will affect the efficiency of operators and supply chains. We'll do this by analysing logistics data and technical information collected through sophisticated computer simulations known as Digital Twins, to help us understand operations at scale."

*Source www.gov.uk

Read the full article at
www.eng.cam.ac.uk/news/electric-hgv-trial

Credit: Sofia Medina Cassillas, PhD student at the Whittle Laboratory

Award-winning PhD research could help inform future design, development and operation of aero engines

↑ LEFT: Abigail attaches pneumatic tubing to a DSA (pressure acquisition system) for measuring static and pneumatic pressures. RIGHT: Abigail attaches a probe to a holder to measure total pressure loss.

With the aviation industry having adopted the goal of reaching net zero carbon emissions by 2050, PhD student Abigail Berhane has been working in collaboration with Rolls-Royce to tackle the problem of 'surface roughness' on the aerodynamic performance of gas turbine blades.

Surface roughness influences engine performance – it is a contributing factor to the amount of specific fuel consumed by a gas turbine aero engine to generate thrust. Gas turbines are widely used in aircraft propulsion and power generation.

Abigail's experimental methodology: 'scan; scale; print; measure', enables any engine component to be scanned in high resolution, preprocessed/scaled, 3D printed and then measured in a wind tunnel. This new method supersedes traditional methods adopted by the gas turbine industry, which were used for assigning an aerodynamic penalty to a rough surface.

Abigail, who is from the Department's Whittle Laboratory, was recently presented with a PhD Student Award For Applied Research by the Cambridge Society for the Application of Research (CSAR), along with the sum of £1,000 to support her in the final stages of submitting her PhD.

Read the full article at:
www.eng.cam.ac.uk/aero-engines

Professor Albert Guillén i Fàbregas awarded European Research Council funding

The European Research Council (ERC) has announced the names of outstanding research leaders to be awarded ERC Advanced Grants. The funding is amongst the EU's most prestigious and competitive, providing leading senior researchers with the opportunity to pursue ambitious, curiosity-driven projects that could lead to major scientific breakthroughs. The new grants, worth in total nearly €652 million, are part of the EU's Horizon Europe programme.

Albert Guillén i Fàbregas, Professor in Communications and Information Theory, is among four Cambridge researchers who have won an ERC Advanced Grant.

Titled *Scaling and Concentration Laws in Information Theory*, he explains his project below:

"A notion embedded in Shannon's and most work in information theory is the very concept of rate, defined as the exponential growth rate of the number of messages to transmit or compress. The probabilistic law governing general information processing systems may be such that the optimal number of messages does not scale exponentially with the length of the sequences. The vast majority of the Information Theory literature assumes an exponential number of messages and thus, ignores the rich amount of possible scaling functions in many important settings. The main aim of this project is to develop a fundamental understanding of rate and error probability scaling. This will not only further develop information theory but will find applications in the efficient design of wireless communications systems where communication is dominated by outages (e.g. WiFi or other indoor scenarios).

"The ERC is genuinely unique in that it generously funds long, ambitious and risky fundamental research projects. I feel honoured and privileged that the ERC continues to fund my research in information theory."

Read the full article at:
www.eng.cam.ac.uk/albert-fabregas

Honours, awards and prizes

2024 Parmee Prize

PhD student Sara AlMahri has won the 2024 Parmee Prize for Entrepreneurship and Enterprise – awarded for her start-up Revco – alongside co-founder Thomas Barber. They presented their business idea at Pembroke (hosts of the Prize).

The Prize has been set up by Pembroke alumnus Dr Richard Parmee, who encourages and nurtures students at different stages of their studies into the world of entrepreneurship. The Prize is also supported by fellow alumnus Robert Marshall.

Revco is an AI tool designed to tackle time-consuming and labour-intensive work creating Bill of Quantities documents for take-off stages in construction projects. Sara and Thomas say Revco marks the dawn of "a new era of a connected, efficient construction industry" by bringing automation to an otherwise outdated, manual process.

Turing Fellow announced

Professor Matthew Juniper has been appointed as a fellow of The Alan Turing Institute. Turing Fellows are the next generation of world-leading researchers. They have proven research excellence in data science, AI, or a related field.

Professor Juniper's fellowship sits within the 'Fundamental AI' priority theme at the Turing, which aims to advance the models, techniques, and principles that underpin AI. As well as being appointed a fellow, he has been seconded to the Turing for research on programmable inference.

The Turing Fellowship Scheme aims to grow the data science and AI ecosystem in the UK by supporting, retaining and developing the careers of the fellows.

King's Birthday Honours

Academics from and affiliated to the Department have received CBEs in the King's Birthday Honours 2024.

Professor P John Clarkson, Director of the Cambridge Engineering Design Centre and Co-Director of Cambridge Public Health. He is known for his research in health and care improvement, inclusive design and systems design, and is honoured for his services to Engineering and Design.

Professor Peter Guthrie, Director of Research in Sustainable Development. His research is focused on the assessment of large-scale projects for sustainability, resilience of infrastructure, and energy efficiency in buildings. He is honoured for his services to Engineering.

Professor Ian White, Honorary Professor of Communications. His research interests include photonics; optical communications; lasers; systems, technology, and devices for optical telecommunications. He is honoured for his services to Higher Education and Engineering.

Royal Society Fellows

Mihaela van der Schaar, John Humphrey Plummer Professor of Machine Learning, Artificial Intelligence and Medicine, and George Malliaras, Prince Philip Professor of Technology, have been elected as Fellows of the Royal Society.

Sir Adrian Smith, President of the Royal Society said: "I am pleased to welcome such an outstanding group into the Fellowship of the Royal Society. This new cohort have already made significant contributions to our understanding of the world around us and continue to push the boundaries of possibility in academic research and industry."

STEM for BRITAIN

PhD students Teja Potočnik and David Hardman showcased their engineering research at Parliament to politicians and a panel of expert judges, as part of the STEM for BRITAIN poster competition.

Teja presented her research poster titled *Automated manufacture of semiconductors using nanomaterials*. David's was titled *Artificial robotic skins – hydrogels that sense and heal*.

Former MP Stephen Metcalfe said at the time: "These early career engineers are the architects of our future, and STEM for BRITAIN is politicians' best opportunity to meet them and understand their work."

Best Paper Award

Assistant Professor James Taylor (pictured) and his co-authors Anthony Dickens and Harry Simpson (previously of the Whittle Laboratory and Rolls-Royce) won the Best Paper Award for *Compressor Tip Leakage Mechanisms* at the 2023 Turbo Expo.

Professor Taylor said: "Tip leakage flows can be responsible for one-third of the inefficiencies within axial compressors, and so understanding them is extremely important for gas turbines, aircraft engines, industrial machines and future zero carbon cycles."

→ THEIA is a student business idea for a new and improved cane for the visually impaired, combining mobility and sensing into one sleek design

Credit: Ria Bacharach, Emily Darnell, Duncan Greenshields and Anders Nielsen

Institute for Manufacturing Design Show 2024

Teams of three or four Manufacturing Engineering Tripos students complete a major design project to develop a new product with real business potential.

Each group conducts market research, develops actionable design ideas and puts together a full business plan. They then create displays to explain the technical ideas and business potential behind their design work. Students are encouraged to produce and show working prototypes wherever possible.

Some of the 2024 projects are outlined below, summarised by the students in their own words.

THEIA

THEIA (pictured) is a new and improved cane for the visually impaired, combining mobility and sensing. Assisted sweeping technology reduces the risk of repetitive strain injuries. Street-level ultrasonic sensing enhances the feedback of every sweep.

Canes are widely used among visually impaired people to sense the world around them and allow independence and safety when navigating spaces, but the standard cane is not much more than an aluminium tube that has barely changed in decades. THEIA was created to directly solve the problems that current cane users experience, and fix the glaring absence of relevant modern technology in this area.

The assistive sweeping comes in the form of a motorised end tip, which reduces the effort required from users without overshadowing the familiar, real-time feedback provided by the cane itself. In the handle, controls give the user full control over how much sweep assistance they receive as well as the timing, allowing users to align the cane's movements with their stride.

Obal

Obal is a one-stop-shop sustainable packaging solution. It is a mechatronic device that can take any sized object (within set parameters) and package it efficiently using single-walled corrugated cardboard, creating right-sized packaging and eliminating excess space in the box.

It is estimated that most companies are using boxes 25% bigger than required for their products; this leads to up to 25% fewer boxes being able to fit in a delivery vehicle, and additional materials like packing peanuts needed to fill excess space.

Obal reduces wasted space within packages and thus allows more items to be loaded and moved. Users input their product dimensions and then Obal calculates the optimal net size, and cuts, folds, forms and seals the box.

The RoboSnake

The RoboSnake utilises advanced articulated modules and integrated sensors to navigate and perform complex tasks in environments that are inaccessible or hazardous to humans.

Disaster response, infrastructure maintenance, and military operations require robotics that excel where humans face limitations.

The RoboSnake features a modular design, which is connected using innovative wrist joints, enabling it to mimic the biological movements of a snake and traverse narrow and complex spaces with unparalleled agility. Its advanced sensors and proprietary navigation algorithms enable real-time control while manoeuvring through unstable terrains and obstructed pathways.

TheLittleDotCo.

TheLittleDotCo. is a low-cost solution to producing braille on a wide variety of paper types, both thick and thin. The desktop printer uses PLA extrusion technology to create small raises on the paper, differing from conventional indenting methods.

There are an estimated 43 million blind or visually impaired people in the world. Less than 10% of those can read braille. Braille literacy has a direct impact on employment. There is a 90% employment rate for those who can read, compared with a 35% employment rate for those who cannot.

TheLittleDotCo. aims to help solve this problem by providing low-cost printing services to allow for more children and adults to learn braille.

→ **Read the full article at:**
www.eng.cam.ac.uk/design-show-2024

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