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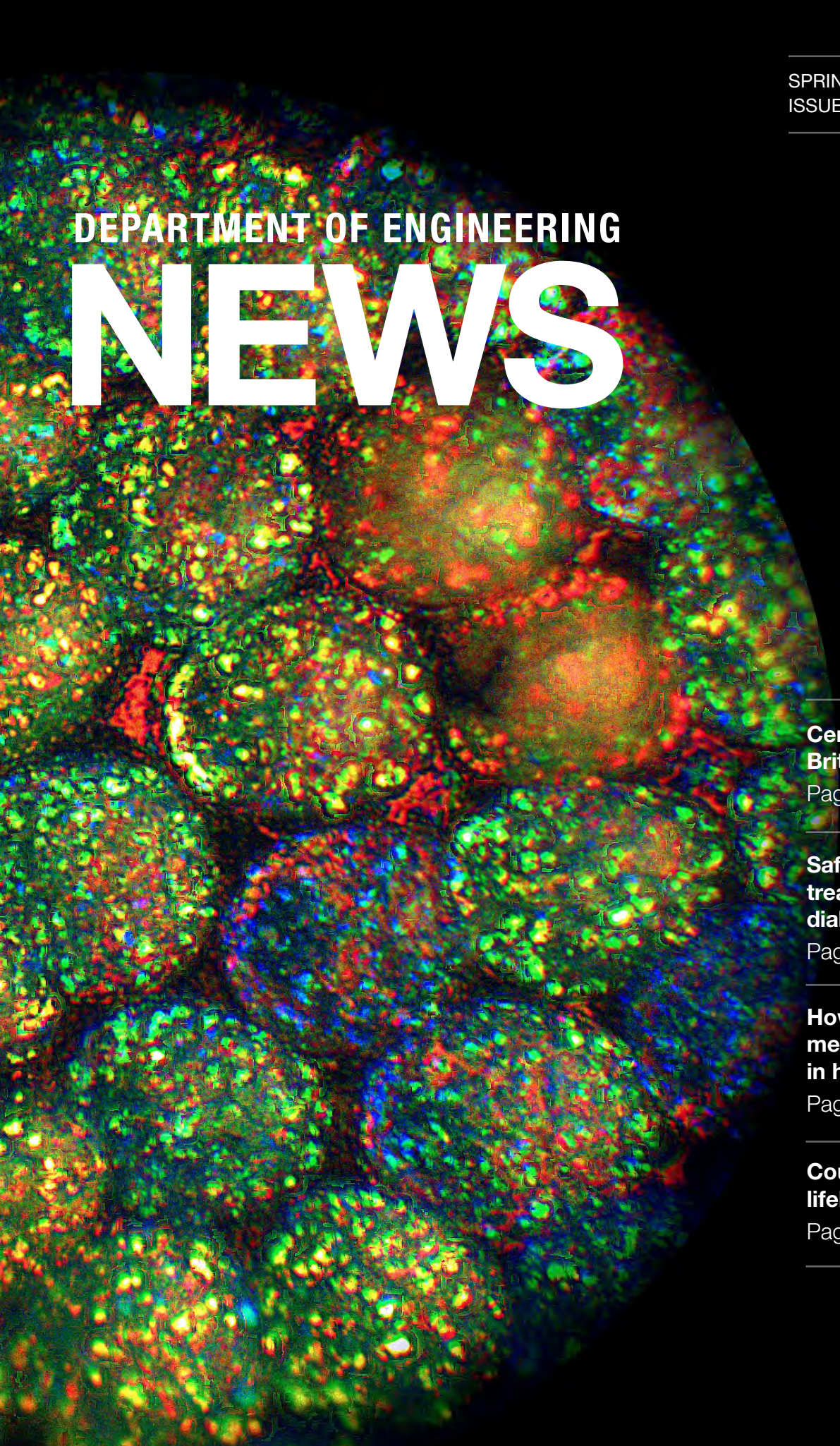

UNIVERSITY OF CAMBRIDGE

In this issue

Cover image: Yin Chang: *Photonic Crystals of Pachyrhynchus Sarcitus Beetles, Taiwan*, shortlisted in the ZEISS Photography Competition 2017.

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Welcome

There has been much in the news lately about healthcare, with the UK's National Health Service under pressure to meet growing demand within its budget. Engineers are all too familiar with this challenge in design, production and service delivery across their traditional sectors.

I'm thrilled that my colleagues are now making significant contributions to healthcare. Stories in this edition show how they are teaming up with colleagues in clinical medicine and healthcare to find new ways forward. We are working at the level of systems and processes, but also delving into new medical understanding and treatments at the nanoscale. Professor Michael Sutcliffe ran a bioengineering conference in March which drew researchers together from across the engineering, biology and medical communities. The event was packed for the whole day and generated a real buzz.

Helen Morton, an alumna of the Department of Engineering, gave a generous donation to enable this meeting, and came along on the day to see the presentations, hear the discussions and meet the researchers.

More is in the pipeline as our bioengineering theme gains momentum, with plans shaping up for our move to West Cambridge and connections to the biomedical campus.

The stories in this newsletter show that we are pushing ahead on many fronts. I continue to be amazed by the capacity of my colleagues for creativity and engagement with new partners.

The closing item for this edition considers the possibility of engineering 'replicants' as seen in the film *Blade Runner 2049*. To quote a famous line from the final scene of the original *Blade Runner*, I've not yet "…watched C-beams glitter in the dark near the Tannhauser Gate", but every week in this extraordinary department, "I've seen things you people wouldn't believe".

Professor David Cardwell FREng

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Credit: pixabay

Centre for Digital Built Britain at Cambridge

The Government has announced £5.4 million in funding to enable the launch of a centre of excellence in Cambridge to champion the digital revolution in the built environment.

The Centre for Digital Built Britain is part of a landmark Government-led investment in growing the UK's construction sector. It is a partnership between the Department of Business, Energy & Industrial Strategy and the University of Cambridge to support the transformation of the construction sector using digital technologies to better plan, build, maintain and use infrastructure.

The Centre will focus on the ongoing transformation of the built environment through the digital tools, standards and processes that are collectively known as Building Information Modelling (BIM). It will continue the work of the Digital Built Britain Programme and the UK BIM Task Group to support delivery of the Government's Digital Built Britain Strategy.

The strategy seeks to digitise the entire lifecycle of our built assets; finding innovative ways of delivering more capacity out of our existing social infrastructure, dramatically improving the way these assets deliver social services to provide improved capacity and better public services. Above all, it will enable citizens to make better use of their cities and infrastructure.

Led by Professor Andy Neely, Pro-Vice-Chancellor: Enterprise and Business Relations, the Centre builds on the expertise and experience of faculty from the Cambridge Centre for Smart Infrastructure and Construction (CSIC), Cambridge Big Data, the Distributed Information and Automation Lab (DIAL), the Cambridge Service Alliance (CSA) and the Institute for Manufacturing (IfM) to form a Research Bridgehead.

The Bridgehead works with a team of specialists from Digital Built Britain Programme, and partners from industry and academia, to develop and demonstrate policy and practical insights that will enable the exploitation of new and emerging technologies, data and analytics. The aim is to enhance the natural and built environment, thereby driving up commercial competitiveness and productivity, as well as citizen quality of life and wellbeing.

Dr Jennifer Schooling, Director of CSIC, said: "The construction and infrastructure sector are poised for a digital revolution, and Britain is well placed to lead it. Over the next decade advances in BIM will combine with the Internet of Things (IoT), data analytics, data-driven manufacturing and the digital economy to enable us to plan new buildings and infrastructure more effectively; build them at lower cost; operate and maintain them more efficiently; and deliver better outcomes to the people who use it."

"This is a wonderful opportunity to put the breadth of research and industry engagement expertise from Cambridge at the heart of Digital Built Britain," she added.

The Centre for Digital Built Britain will continue to build on this transformative approach and will be based in the Maxwell Centre in West Cambridge.

> This is a wonderful opportunity to put the breadth of research and industry engagement expertise from Cambridge at the heart of Digital Built Britain.
>
> Dr Jennifer Schooling, Director of CSIC

www.eng.cam.ac.uk/profiles/adn1000
www.eng.cam.ac.uk/profiles/jms33
www.cdbb.cam.ac.uk

New President of the Institution of Civil Engineers

Credit: CSIC

Professor Lord Robert Mair CBE, head of the Department's Centre for Smart Infrastructure and Construction (CSIC), has become the 153rd President of the Institution of Civil Engineers (ICE).

His presidency coincides with the 200th anniversary of the ICE, a body that aspired to meet, head on, the challenges of the day: poor social conditions and health, community division and new engineering possibilities.

Professor Lord Mair, whose engineering career spans more than 40 years, gave his President's Address on the theme 'Transforming Infrastructure, Transforming Lives – Building on 200 years' and set out his objectives for his year of office. He discussed the challenges of the 21st century: climate change, population growth and rapid urbanisation and how civil engineers can transform for the better the lives of millions of people.

He also outlined how civil engineers today are as innovative and dedicated to solving problems now as they ever were, and he touched on how the profession can use technology to improve infrastructure assets, transforming the industry, and transforming the societies it serves.

Last, he set out the opportunity for the civil engineers of today to solve the current global challenges and encouraged the next generation to rise to these challenges by becoming engineers.

"Throughout my career, I have seen first hand how engineers can transform lives and I'm excited at the prospect of a whole new era of smart technology," said Professor Lord Mair.

"I plan to use the opportunity of my presidency to help make the profession of civil engineering fit for a digital future and ready for the potential changes to the way infrastructure is delivered.

"I see a great and vibrant future for our profession; for infrastructure and for the lives of every person on this planet, regardless of who they are or where they were born. The challenge now is to encourage young people from all backgrounds to join us in this profession, one which has the power – and the responsibility – to literally change the world for the better."

Page 6
Meet one of Professor Lord Mair's 'Future Leaders'

> The challenge now is to encourage young people from all backgrounds to join us in this profession, one which has the power – and the responsibility – to literally change the world for the better.
>
> Professor Lord Robert Mair CBE

www.eng.cam.ac.uk/profiles/rjm50
www-smartinfrastructure.eng.cam.ac.uk
www.ice.org.uk

→ Professor Ferrari during the flight

Credit: Graphene Flagship

Zero gravity graphene promises success in space

In a series of exciting experiments, Cambridge researchers experienced weightlessness testing graphene's application in space.

Working as part of a collaboration between the Graphene Flagship and the European Space Agency, researchers from the Cambridge Graphene Centre have tested graphene in microgravity conditions for the first time.

Testing graphene's potential in cooling systems for satellites, the researchers experienced weightlessness inside a parabolic flight – also known as the 'vomit comet'.

"Graphene as we know has a lot of opportunities. One of them, recognised early on, is space applications, and this is the first time that graphene has been tested in space-like applications, worldwide," said Professor Andrea Ferrari, Director of the Cambridge Graphene Centre.

Professor Ferrari is also Science and Technology Officer and Chair of the Management Panel for the Graphene Flagship.

Graphene – the single-atom thick allotrope of carbon – has a unique combination of properties that make it interesting for applications from flexible electronics and fast data communication, to enhanced structural materials and water treatments. It is highly electrically and thermally conductive, as well as strong and flexible.

In this experiment, the researchers aimed to improve the performance of cooling systems in use in satellites, making use of graphene's excellent thermal properties.

"We are using graphene in what are called loop-heat pipes. These are pumps that move fluid without the need for any mechanical parts, so there is no wear and tear, which is very important for space applications," said Professor Ferrari.

"We are aiming at an increased lifetime and an improved autonomy of the satellites and space probes. By adding graphene, we will have a more reliable loop heat pipe, capable of operating autonomously in space," added Dr Marco Molina. Dr Molina is Chief Technical Officer of the Space line of business at Leonardo, an industry partner of the experiment.

In a loop-heat pipe, evaporation and condensation of a fluid is used to transport heat from hot electronic systems out into space. The pressure of the evaporation-condensation cycle forces fluid through the closed systems, providing continuous cooling.

The main element of the loop-heat pipe is the metallic wick, where the fluid is evaporated into gas. In these experiments, the metallic wick was coated in graphene providing two benefits improving efficiency of the heat pipe. First, graphene's excellent thermal properties improve the heat transfer from the hot systems into the wick. Second, the porous structure of the graphene coating increases the interaction of the wick with the fluid, and improves the capillary pressure, meaning the liquid can flow through the wick faster.

After excellent results in laboratory tests, the graphene-coated wicks were tested in space-like conditions on board a Zero-G parabolic flight. To create weightlessness, the plane undergoes a series of parabolic manoeuvres, creating up to 23 seconds of weightlessness in each manoeuvre.

In the flight, the graphene-coated wicks again demonstrated excellent performance, with more efficient heat and fluid transfer compared to the untreated wicks. Based on these promising results, the researchers are continuing to develop and optimise the coatings for applications in real space conditions.

"The next step will be to start working on a prototype that could go either on a satellite or on the space station," said Professor Ferrari.

The research was supported by the Graphene Flagship and the European Space Agency, as a collaboration between researchers from Université libre de Bruxelles, Belgium; the University of Cambridge; the National Research Council of Italy (CNR), Italy; and industry partner Leonardo Spa, Italy.

Watch what happened during the flight:
youtu.be/LKGiDoxlqzw

www.eng.cam.ac.uk/profiles/acf26
www.graphene.cam.ac.uk
http://graphene-flagship.eu/
www.esa.int/ESA

ALUMNI UPDATE

Alumna recognised by New Civil Engineer and the Institution of Civil Engineers

Credit: New Civil Engineer

Alumna Charlotte Murphy (Girton, 2016) has been named New Civil Engineer Consultant Graduate of the Year 2017.

Charlotte was one of three winners selected from more than 100 graduates representing 49 different companies. All the finalists were judged on their academic and engineering skills, with emphasis placed on their enthusiasm, initiative and leadership potential.

The graduate bridges engineer works for Arup as part of its civil structures, bridges and tunnels team.

Charlotte was also picked to work closely with New Civil Engineer and the Institution of Civil Engineers (ICE) to focus on 'outside work engineering', her chosen priority for the year. She aims to set up a conference and awards event celebrating engineers' extra-curricular community engagement and research activities.

"It's really exciting to have been recognised for my passion for the civil engineering profession and to be given a platform to help me improve the awareness of the great work that engineers do in their free time," she said.

"Engineering skills are incredibly useful and transferable. Engineers do incredible things inside and outside of their commercial projects. The work outside of commercial projects currently has no platform within the industry. I would like to change this to ensure not only that people get the recognition that they deserve, but also to showcase how engineering skills enable you to achieve."

Future leader

Charlotte has also been selected as one of ICE President's (Professor Lord Robert Mair) Future Leaders for 2017-18, in which she will learn more about the civil engineering industry and its impact on society. Professor Lord Mair is head of the Department's Centre for Smart Infrastructure and Construction (CSIC).

Speaking about the role, she said: "This is such a fantastic opportunity to learn from an engineer that I respect so highly. Through my involvement in Project 13 I'm learning about policymaking which is very different to the technical side of the industry that I am used to. It is really interesting and I'm looking forward to getting more involved."

Charlotte, who recently became a reserve army officer in the Royal Engineers, credits her Cambridge experience as having helped to mould her into the engineer she is today.

"A great thing about the Cambridge engineering course is that you need to gain work experience during the course," she said. "This means that you get good exposure to different industries so you can work out where your interests lie. These work placements helped me to appreciate the challenges of different industries and find out what I was passionate about.

"Being an engineer is a very satisfying career as you are working to create something that will benefit society. It is real, you can touch it, and you can visit a project in 50 years and know that you were part of the team that made it happen."

www.newcivilengineer.com
www.ice.org.uk

→ Sonja at work in the lab

Credit: Sonja Kinna

Self-assembling peptides and the fight against obesity and diabetes

A collaboration between the Department's Nanoscience Centre and MedImmune is taking great strides towards safer and more effective treatment of type 2 diabetes and obesity.

The Cambridge chemical engineers have been studying oxyntomodulin, a human peptide, which has the potential to be a safe and efficient form of treatment for both type 2 diabetes and obesity. One of the advantages of the new drug is that, unlike other treatments for type 2 diabetes, it will not cause the patient to gain weight – in fact, quite the opposite.

"There is evidence that oxyntomodulin both reduces appetite and causes a slight raising of body temperature and increase of the heart rate, which will help with weight loss," says Sonja Kinna, a final-year PhD student, supervised by Professor Sir Mark Welland, who is investigating peptide self-assembly as a long-term drug formulation. "In addition to treating diabetes, we see it as a potential weapon to fight obesity."

Sonja and the team have been examining the structural properties of the peptide, which can be stored in a fibrillar (or linear) structure. This structure is inert, but disassembles into a soluble state on being injected under the skin, triggering the release of insulin in the body.

The traditional treatment of type 2 diabetes involves injecting insulin directly into the patient. If too much insulin is applied, the patient can develop hypoglycaemia, but oxyntomodulin eliminates that risk by causing the patient's body to produce its own insulin and balancing insulin production.

"We know peptides are a very safe and effective form of treatment," says Sonja, "but the problem is that the body reacts to them as it would to proteins, treating them as food and therefore breaking them down. That's why the ability to use oxyntomodulin's fibrillated form is so important. We can use it as a depot from which the active peptide diffuses into the bloodstream over an extended period."

Slow release from self-assembled structures creates a sustained action that circumvents the short half-life of peptides. This means the effect of the drug may last in humans for several days or even weeks. Although the drug is potentially effective in its free form, it would have to be administered frequently, perhaps as often as every four hours.

The team's paper, *'Controlling the bioactivity of a peptide hormone in vivo by reversible self-assembly'*, won the Medimmune 2017 Global Excellence Award for the best publication of the year. The award recognises exceptional contributions to advance innovative science and deliver tremendous value to the MedImmune organisation.

"The best thing about this project has been the collaboration with MedImmune," says Sonja. "It's great because we [at Cambridge] study the structure of the peptides at a nanoscale, whereas the biologists from MedImmune look at the risk factors involved from an industry point of view. Together it works very well."

The partnership is proving beneficial to both the University and MedImmune, and is potentially life-changing for millions.

"This work demonstrates how University research with a commercial partner can innovate medicine," says Professor Sir Mark Welland. "Our years of research on how proteins and peptides can form nanostructures has allowed us to take a potential medicine and redesign its delivery so as to make it far more effective."

The Cambridge team uses atomic force microscopy to track signals and create images of the fibrils, which cannot be seen at all, even using the most powerful of optical microscopes. They also investigate the kinetics and thermodynamics of fibrillation and peptide release to better understand how they operate under various conditions.

There is, of course, much work to be done before any drug could appear on the market, and it must be carried out under very precise conditions. It is vital work, however. Not only does this study hold hope for better treatment for those suffering diabetes, but it also has implications for understanding diseases such as Parkinson's Disease, which are caused when proteins fibrillate irreversibly.

www.eng.cam.ac.uk/profiles/mew10
www.eng.cam.ac.uk/profiles/sk793
www.nanoscience.cam.ac.uk

Credit: pixabay

How an open approach to patents could help build a sustainable future

Dr Frank Tietze, Lecturer in Technology and Innovation Management at the Institute for Manufacturing (IfM), writes for *The Conversation* on an open approach to intellectual property (IP).

To sustain a population of 9.7 billion people by 2050 the world is going to need innovations that make careful use of the available resources, human and environmental. Key industry sectors such as energy, water, agriculture and transport are already under pressure to move to more sustainable methods of production and consumption. The transitions to more sustainable trajectories needs to be supported by careful chosen approaches to IP.

The 'classical' approach to IP is the protection of inventions by patents and often used to prolong the life cycle of existing technologies, and allow innovators to capture the profits from their creations. However, this is only one way and sometimes it can be very helpful to share IP openly. For instance, electric car manufacturer Tesla has been doing just that. Tesla CEO Elon Musk "shocked" the world in 2014 when he announced that his company was joining the open source movement and giving away its patents for free. In a paper published with colleagues from universities in Germany and India, we examined how different approaches to IP can support the development and diffusion of new and more sustainable technologies to be developed and adopted.

Tesla initially developed a patent portfolio to protect its technology. Just about when the electric car market stagnated at less than 1% of total vehicle sales, Tesla changed its strategy from trying to prevent others from building electric cars using their technology to trying to encourage them into the market.

Part of the reasoning here is that if more electric cars are built, then more battery recharging stations will be built too. This would make electric cars become more visible, and a more conventional choice. One explanation for Tesla's strategy change is that an open intellectual property strategy can strengthen rather than diminish its position by building the size of the electric car market, and as a result, build its own share of the total automotive market.

This kind of careful management of intellectual property at company level, supported by policy-level awareness, can be a powerful way to support the same kinds of transitions to more sustainable technologies in other industries too.

Energy supply faces an array of difficulties: the depletion of natural resources; air pollution and greenhouse gas emissions; nuclear risks; and security of supply.

In order to navigate a path around these problems, new knowledge and the innovations that follow will be essential, but not only the development of this knowledge, but also its diffusion and adoption. In essence, in knowledge economies, intellectual property needs to be managed carefully by companies and policymakers so it can be an enabler rather than an inhibitor for sustainability transitions.

If the ownership of IP is fragmented in an industry, it can slow down technology innovation and uptake, such as in the electronics industry where multiple players own complementary patents. However, firms can instead open up their innovation processes and move away from guarded, internal cultures, where intellectual property is used to protect and prolong lifecycles.

This approach to intellectual property, so-called 'open IP', is reasonably advanced and mature in the software industry and healthcare.

In certain situations it has advantages in popularising and establishing new and widespread sustainable technologies, but as progress in technology is often cumulative, it is likely that there are cases or phases where 'closed IP' strategies are necessary, such as for small companies to build up their portfolio. This can also be a strategy designed to make a social impact. Take Nuriset, which manufactures food for famine relief. It protects its invention, a peanut-based paste for the treatment of severe malnutrition, Plumpy'Nut, by patents, primarily to protect its business model.

The grand open IP gestures in the mould of Tesla can force through rapid structural advances; a small peanut paste supplier shows that patent protection can still help put the building blocks in place. Which IP models companies and governments employ under which conditions is part of a central research question at the IfM's Innovation and Intellectual Property Management group.

www.eng.cam.ac.uk/profiles/ft263
www.ifm.eng.cam.ac.uk

→ Gates Cambridge Scholar Paulo Savaget

Sustainability hacking for a better healthcare system

How do you get medicines to the poor in hard-to-reach areas?

This is an issue which has been looked at by Gates Cambridge Scholar (2015) Paulo Savaget as part of an action research project in Zambia with the charity ColaLife. The charity aims to emulate the value chains of fast-moving consumer goods, such as Coca-Cola, to get much needed over-the-counter medicines to people in remote areas in low-income regions.

Paulo, who is currently studying for a PhD in Engineering at the University of Cambridge, and his supervisor Professor Steve Evans, Director of Research in Industrial Sustainability, have won a $20,000 award from the IBM Center for The Business of Government for their project titled *Catalysing Access to Medicines by Emulating Value Chains of Fast-Moving Consumer Goods*.

The award involves creating a roadmap for 'sustainability hacking' – finding ways around the bottlenecks in social and technological systems that achieves immediate results. The roadmap will be based on the action research project carried out in Zambia, with the overall aim being to use it to scale up the project across other Sub-Saharan countries.

For his PhD, Paulo interviewed ICT hackers and cybersecurity experts to see how hacks can be applied to areas such as health, education, gender empowerment and to combat corruption. After developing his new concept, Paulo has been working with sustainability hackers to understand how they have been addressing some of our most pressing sustainability challenges.

The action research project in Zambia came about because of the difficulties faced by people in remote areas trying to get access to over-the-counter medicines. Diarrhoea, for example, can often be treated with over-the-counter medicines but is the second biggest killer of children under five in Sub-Saharan Africa.

The project looked at how medicines could piggyback on the distribution networks of Coca-Cola, which in comparison has no problem getting into rural areas. Medicines were initially designed to fit in between Coke bottles. Then the project mapped the value chain for fast-moving consumer goods to the value chain for diarrhoea treatment. The project significantly increased access to the medication in Zambia.

The main bottleneck for getting access to medicines is poor infrastructure and governance. Paulo says the mainstream and ideal approach would be to improve the country's infrastructure to provide the medicines through a comprehensive healthcare system. However, this would also take many years or might not happen at all. That is where hacking comes in as it circumvents the bottleneck to arrive at a more immediate solution that is 'good enough'.

"Our aim with this roadmap is to empower people to catalyse system change so that it expands access to healthcare," added Paulo. "We need to understand how the immediacy of hacks can be fostered systematically."

The roadmap will trace how the value chains used to distribute Coca-Cola could be emulated, including manufacturers, shopkeepers, community health workers, government agencies and many other stakeholders. Paulo is also looking at things that could have an impact on accessibility, for instance, political changes, which are harder to control, and policy frameworks and regulations that could be influenced. In addition, he is considering what else could make a difference, for instance, 'nudge theory' to change behaviour and human-centred design.

Credit: Simon Berry

↑ Baby with an anti-diarrhoea kit in Katete, Eastern Province, Zambia

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www.gatescambridge.org
www.colalife.org

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Improving the shopping experience on mobiles

↑ Examples of Mobile Ready Hero Images

Shopping on mobiles could become easier thanks to a new global standard for product images.

Product sales on mobiles continue to grow, but conventional photographs of products often fail to provide key information to shoppers. In response, the Inclusive Design Group at the Department's Cambridge Engineering Design Centre has developed a proof of concept for improved Mobile Ready Hero Images, in collaboration with Unilever.

Mobile Ready Hero Images are designed to speed up grocery shopping on mobiles.

Dr Sam Waller, Senior Research Associate in the Inclusive Design Group, explained: "Mobile Ready Hero Images make it easier for shoppers to identify critical product information like brand, product type, flavour/variant and size. While traditional pack photographs can be effective on large desktop screens, different flavours and sizes of products can look identical when these photographs are displayed on mobiles, reduced to the size of a postage stamp. This is especially problematic for older consumers with age-related long sightedness."

Oliver Bradley, e-commerce director at Unilever, said: "To date, Mobile Ready Hero Images have been adopted by over 83 retailers in more than 40 countries worldwide. Magnum ice cream is one of Unilever's billion dollar global brands that has adopted hero images. During an eight-week A/B split test with a retailer, Magnum's hero images led to a sales increase of 24%."

In order to meet retailers' demands for consistent product images across all brands, Unilever commissioned Cambridge to develop a website for hero image guidelines. This contains freely available templates to help brands quickly create improved product images.

Some brands have fast-followed Unilever and created Mobile Ready Hero Images using the Cambridge templates, while others have developed hero images in a completely different way. Some retailers have chosen to accept all kinds of hero images, while others will only accept some kinds of hero images. This results in an inconsistent experience for consumers.

Paul Reid, head of standards at GS1 in the UK, explained: "We spotted the opportunity to improve this situation using our Global Standards Management Process. This involves setting up a working group to gather agreement between competing brands and retailers, leading to a single, globally applicable set of guidelines for Mobile Ready Hero Images. These guidelines will help brands and retailers make the shopping experience more consistent, and therefore, better."

Dr Waller explained how Cambridge research will help to inform this process: "Inclusive design can help improve the visual clarity of hero images, making them more accessible to a wider range of consumers. In particular, our SEE-IT method can estimate the proportion of the population who would be unable to discern the critical information from e-commerce images. We are looking forward to contributing our expertise to the GS1 working group to help inform the critical decisions."

"Grocery products are just the start," he added. "We are aiming to improve the e-commerce images used for every product, in every retailer, in every country in the world."

Watch this introduction to Mobile Ready Hero Images:
youtu.be/1223GTQQctE

www-edc.eng.cam.ac.uk/people/sdw32.html
www.unilever.co.uk
ecommerce.inclusivedesigntoolkit.com
www.gs1.org/standards-development-work-groups#HERO

→ Bernard Taylor, Chairman of the Royal Commission for the Exhibition of 1851, presents PhD student George Roberts with his three-year Industrial Fellowship

PhD student secures Fellowship to aid development of innovative technology

A Cambridge PhD student has been awarded an Industrial Fellowship worth up to £80,000 to help unlock the commercial potential of his data transmitter technology.

George Roberts, who is a student with the EPSRC Centre for Doctoral Training (CDT) in Integrated Photonic and Electronic Systems (IPES), has been named as one of the UK's most promising young doctoral engineers by the Royal Commission for the Exhibition of 1851.

His project – joint with Toshiba Research Europe – is a data transmitter to standardise next-generation quantum communications. It works by sending single particles of light between two parties. Anyone wishing to eavesdrop on the communication will change properties of the light in a manner that will be observable to the legitimate users. This means hacking attempts can be quickly spotted and security tightened.

"I'm working on a technology known as quantum key distribution (QKD), which enables perfectly secure telecommunications based on the fundamental laws of physics; hence QKD-encrypted data is future-proof," said George.

"Developments to QKD will likely involve networks comparable to today's internet, where many different users can communicate with one another securely. Unfortunately, a number of different methods of implementing QKD have been developed, each with their own benefits, but each with a different transmitter and receiver. This would make a network overly complicated and expensive if all users are to be linked.

"The technology that I've worked on, joint with Toshiba Research Europe, allows all different types of QKD to be implemented using a single transmitter. This would greatly simplify future secure networks. Also, this novel transmitter is power efficient, simple and has a small footprint."

The three-year Fellowship will provide George with the means to develop this innovative technology, ideally leading to a patent, while completing his PhD.

George added: "I'm honoured to receive this Fellowship. I will now be able to obtain equipment enabling me to explore novel features of my transmitter in the final year of my PhD. It will also mean that I can present my research at many conferences and this introduces me to a network of Industrial Fellowship alumni."

Dr Seb Savory, Lecturer in Photonics and RF Systems, who supervises George, said: "I'm very happy to see George be awarded this prestigious Industrial Fellowship. He has been an excellent doctoral student and this award will both support his industrially linked research but also its dissemination through travel to leading international conferences."

Professor Richard Penty, Site Director for the IPES CDT, said: "I'm delighted that a student from the IPES CDT has been awarded such a prestigious Fellowship. His work with Toshiba has great potential for the development of much more secure communications networks at the physical level."

Originally set up by Prince Albert following the Great Exhibition of 1851, the Industrial Fellowships recognise the best research that could advance British industry, and funds are awarded to bring projects to market.

> "I'm working on a technology known as quantum key distribution (QKD), which enables perfectly secure telecommunications based on the fundamental laws of physics; hence QKD-encrypted data is future-proof.
>
> George Roberts

→

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www.ipes-cdt.org
www.royalcommission1851.org

The beauty of engineering

↑ First Prize, video submission by Bryn Noel Ubald: An instrumented turbine blade – a unique perspective…

Creative images and video spanning tissue engineering, aircraft engines and nanotechnology have won prizes in the Department's 2017 ZEISS Photography Competition.

First Prize was awarded to PhD student Bryn Noel Ubald for his video which shows how fluid behaves as it moves over a turbine blade with a temperature probe at the front. The video is part of a study which uses high-fidelity computational modelling to understand the impact of measurement devices within aircraft engines.

Fellow PhD student Elisabeth Gill won **Second Prize** with a striking image of micro-scale fibres drawn from a viscous gelatin solution across a 3D printed PLA (Poly(lactic Acid) support structure – the sparkly material you can see along the top of image 1. The goal of her work is to integrate an open source 3D printing platform and a low voltage electrospinning technique to create high resolution, 3D biomaterial fibre 'architectures' to act as part of a tissue scaffold for 3D cell culture.

Research Associate Alex Justin's image of red and blue capillary formation secured **Third Prize**. Alex works in the area of tissue engineering – the in vitro generation of large tissues and organs. This image shows two 'multi-cellular spheroids', made from a large cluster of endothelial cells, which normally coat the internal surface of blood vessels. The spheroids are embedded alongside a large number of fibroblasts into a 3D collagen hydrogel, which is similar to the extracellular matrix of native tissue. The interaction between these cell types induces the endothelial cells to sprout new capillary-sized vessels into the bulk.

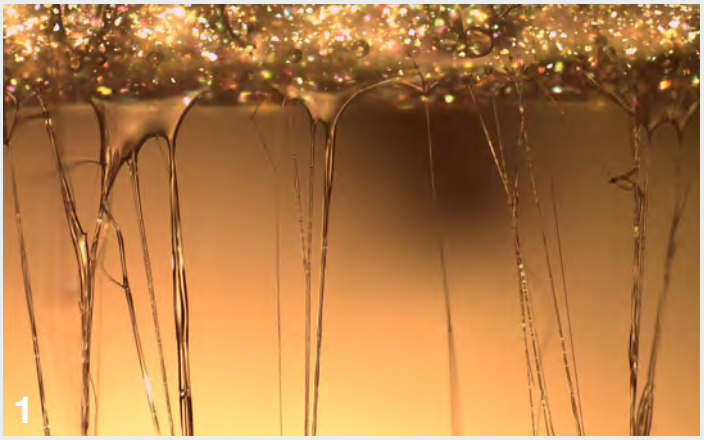
'Small but strong: Nano-Man' certainly caught the judges attention. The intricate micrograph was captured using a scanning electron microscope and was awarded the **SEM Prize**.

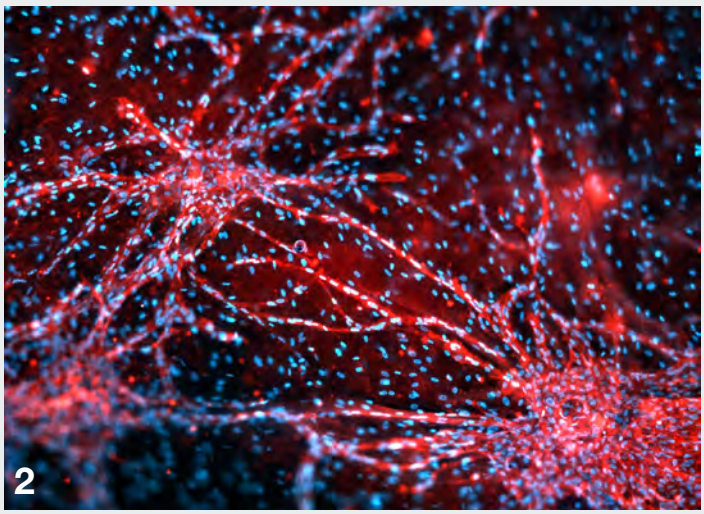
Ravi Chitwan, PhD student at Queen's University Belfast, and Cambridge Research Associate Dr Wei Tan managed to capture thousands of entangled carbon nanotubes (CNTs) in a form resembling a sculpture. CNTs can be best described as seamless hollow tubes comprised of hexagonally arranged carbon atoms. They exhibit extremely useful material properties such as superior strength, high electrical and thermal conductivity. CNTs are 100 times stronger than steel, but only one-sixth as heavy. Using CNTs could ultimately provide improved lightning-strike protection, impact damage resistance, anti-icing capability and integrated structural health monitoring to composite aerostructures.

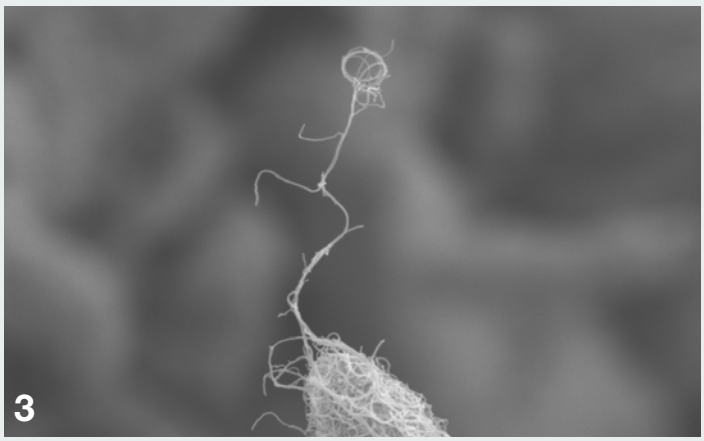
Aude Mulard, former student at the Department of Engineering, won the **Head of Department Prize** with a computer simulation which shows the complex 'fingering instabilities' of a self-propelled fluid pushed against a viscous fluid. The goal of this work is to understand the mechanical process of wound healing and tumour growth. When a tumour grows in one's body, lines of cancer cells may protrude out of the mass, detach themselves from it and begin invading the body. This process is called metastasis, and cancer at this stage is extremely difficult to treat.

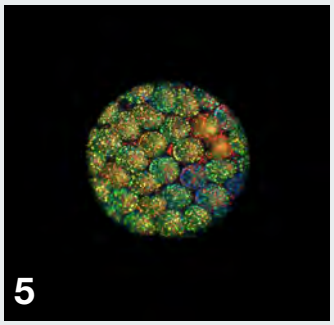
The competition, sponsored by ZEISS (Scanning electron microscopy division), international leaders in the fields of optics and optoelectronics, has been held annually for the last 13 years. The panel of judges included Roberto Cipolla, Professor of Information Engineering, Dr Allan McRobie, Reader in Engineering, Professor David Cardwell, Head of Department, and Philip Guildford, Director of Strategy and Operations.

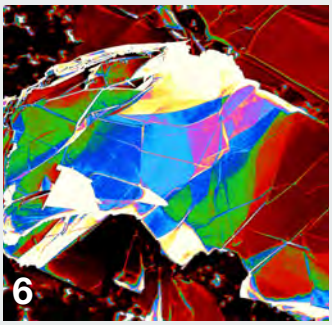
"Once again, I am blown away by the quality of the submissions we received for the photo competition," said Philip Guildford. "Each of these images and video tells a story about the work that our faculty, researchers, students and staff are doing to advance our understanding of the world, and each of those stories is told beautifully."











1: Second Prize, Elisabeth Gill: Gelatin Micro-fibre Initiation

2: Third Prize, Alex Justin: Capillary Formation from Multi-Cellular Spheroids

3: SEM Prize, Ravi Chitwan and Wei Tan: Small but strong: Nano-Man

4: Shortlisted, Michael De Volder: Flowers

5: Shortlisted, Yin Chang: Photonic Crystals of Pachyrhynchus Sarcitus Beetles, Taiwan

6: Shortlisted, D T G Galhena: The Tiger Jigsaw

The winning images and video entries can be viewed on the Department's Flickr and YouTube pages:
www.eng.cam.ac.uk/Flickr
www.eng.cam.ac.uk/YouTube

Credit: Wellcome Collection

A new engineering model for health and social care improvement

↑ One of the wards in the hospital at Scutari (Turkey) (Crimean War 1856)

Applying a more holistic or 'joined-up' systems approach to health and social care provision could help transform the way these essential services are delivered and address the needs of a changing patient population.

This is according to a joint report published by the Royal Academy of Engineering, the Academy of Medical Sciences, and the Royal College of Physicians. Professor of Engineering Design John Clarkson chaired the joint working group that produced the report.

Over the last 20 years, there have been many calls to overhaul the way health and social care are delivered, and to optimise the links between all the constituent parts of the health and care community, but there has been no clear definition of how this might work in practice.

The framework proposed in the report, *Engineering better care*, outlines how a systematic engineering approach could be applied to health and social care, with the potential for transformative effects.

Co-produced by engineers, clinicians, and health and care leaders, it is designed to develop systems that better meet the needs of patients, carers and NHS staff. The thinking behind the report is exemplified by an earlier project where a team of pharmacists, clinicians, patients, engineers, pharmaceutical suppliers and manufacturers used a systems approach to develop safer ways to administer methotrexate for the treatment of rheumatoid arthritis.

The report's proposals are informed by a unique forum of experts, including systems engineers, health and care professionals, quality improvement experts, and patient representatives. Their aim is to develop a new model to support the joined-up design and delivery of health and social care services. The new proposals are systematic, consistently taking into account the four key elements that are vital to improve processes: people, systems, design, and risk.

The work that led to this report has built a network of healthcare and engineering organisations and individuals who will implement and test the new model in healthcare settings over the next few years. For example, the Royal College of Physicians plans to integrate many of the findings into their new Quality Improvement Hub, which will take forward their vision of the Future Hospital.

Professor Clarkson said: "Making systems that work relies on asking questions to understand the context of the challenge, design a competent system, deliver this system into practice and to sustain its utility and use. Such questions typically focus on complementary perspectives on people, systems, design and risk and range from simple narrative enquiry to detailed engineering analysis and simulation.

"The questions presented in this report are the result of years of research and practice of a systems approach and provide a unique insight into the essence of what it is to engineer. The power of the simple question in changing the way people think cannot be overestimated, and changing the way that people think changes what they do. Providing them with tools to put into practice their new ways of thinking then transforms what they can achieve."

In a foreword to the report, the Rt Hon Professor Lord Darzi of Denham says: "I fully endorse the recommendation that healthcare leaders and transformation teams consider the questions and tools laid out here to support a more consistent application of a systems approach to health and care design and improvement. With this work we hope to deliver benefits for patients, carers, and staff, and showcase the value in cross-sectoral working."

Read the report: https://goo.gl/7PaUZb
www.eng.cam.ac.uk/profiles/pjc10

Credit: Johannes Whittam

→ Johannes Whittam on the top of the South Pylon on the Mersey Gateway Bridge

ALUMNI UPDATE

Meet the engineer designing bridges in the UK and abroad

Johannes Whittam will never forget the hands-on construction experience he gained while at Cambridge. Now he's a Senior Engineer and has worked on one of the biggest bridge projects in the UK.

Currently employed by COWI, a leading consulting group, Johannes (Robinson 2012) has carved a successful career in the industry since graduating, working on a variety of projects including Tottenham Hotspur Football Club's new stadium and a number of different bridges of various sizes, the most recent of which has been the new Mersey Gateway Bridge.

Johannes, Master of Engineering (MEng), specialised in Civil and Structural Engineering in the final two years of his degree. Picking up practical construction experience through a project called Constructionarium was a highlight of his degree.

Johannes, what did you enjoy most about your Cambridge degree?

The broad nature of the first two years, covering many different engineering disciplines, has given me a really good foundation for my career. For the Constructionarium project, we got to build a scaled-down version of a real structure; this was one of the most educational and directly applicable parts of the course for me. Getting a real appreciation for how structures are constructed was invaluable when I started work as a bridge designer.

I think the Constructionarium project is really valuable for anyone going on to work as a civil or structural engineer. It gives real, hands-on experience of the methods used in construction.

For designers (like me) it's vital to be able to keep perspective on how easy a design will be to construct, and Constructionarium definitely gave me a head start in this respect.

For contractors, it gives a great insight into how this side of the industry works, what some of the essential parts of the construction process are and how they work.

During the Structural Design module, we got to design a tension structure. This gave me a great appreciation for how to combine function and form; one of the most important factors in elegant bridge design.

How has your career progressed since graduating?

I've recently become a Chartered Engineer with the Institution of Civil Engineers (ICE), picking up a nomination for the James Rennie Medal Award along the way.

For the majority of the last four years I've been working on the Mersey Gateway Bridge, a 1km long cable-stayed bridge over the river Mersey, with 1km of approach viaducts. My roles on this project have changed over time. I've worked on the pylon pad foundation design, the pylon design, and designed the reinforcement in the deck.

For the past year, I've been based on site and have had two roles: managing and answering all the technical queries that the contractor and construction teams want to ask the designers; and Geometry Control. Geometry Control is essentially making sure the ends meet as the balanced cantilevers grow towards each other.

Another project I've worked on was Gaseke's Bridge to Prosperity. This is a 51m suspension footbridge I built in rural Rwanda.

COWI paired up with a contractor and partnered with Bridges to Prosperity. Bridges to Prosperity works to construct footbridges in rural developing countries to provide safe, reliable access to healthcare, education and economic opportunities.

The new bridge will replace the existing temporary crossing which they can use during the dry season (when we were there). It washes away and becomes impassable during the rainy season. Several people had died in recent years at this crossing, including groups of school children on the way home from school.

The new bridge will prevent that from happening by providing safe, year-round access, and that's really exciting. It was hard work in very tough conditions, but it's by far the most rewarding project I've been involved in.

What encouraged you to study Engineering?

I'd always been interested in how stuff worked and why things were built the way they were. I was good at maths and physics and so engineering seemed like a great option.

I wasn't certain what type of engineering I wanted to do, it wasn't something I'd ever studied at school so I wasn't sure if I wanted to be a mechanical, structural or any other type of engineer. That's why the University of Cambridge course was so great; I got to learn all about the different disciplines (getting a great foundation) before making an informed decision about what to specialise in.

→ From left: Siddharth Gupta, Gwilym Rowbottom, and Joshua de Gromoboy

Credit: The IET

Undergraduates' invention wins challenge

Three Cambridge students have won a cash prize in recognition of their engineering solution to a problem often faced by humanitarian relief agencies tackling challenging terrain.

Fourth year undergraduates Siddharth Gupta, Gwilym Rowbottom and Joshua de Gromoboy entered the Institution of Engineering and Technology's (IET) Young Professionals Global Challenge with their invention 'Weigh2Go' – an on-board device that can gauge a vehicle's weight to ensure it is loaded correctly and safely.

The team's device takes a unique approach to the problem being faced by humanitarian relief agencies by analysing the vibrational response of the car to a known input force – a principle not currently undertaken by any commercially available solution.

The trio from Pembroke College, who formed the 'Good Vibrations' team, were announced the winners of the global engineering challenge. They each received a prize of £250 and were presented with their trophy and a certificate at the IET Innovation Awards earlier this month.

Young professional engineers (aged 18-35) from across the globe were challenged to develop a device that can accurately and actively gauge the load weight in a Toyota Land Cruiser or similar, enabling the driver to visually identify when the vehicle is safely loaded and alert the driver if the vehicle is overloaded.

The competition scenario was developed in partnership with international NGO, RedR.

The vibration unit comprises of two offset masses in a steel case, which are mounted to the car chassis. By rotating the masses, the car is forced to vibrate and the response is recorded using the on-board accelerometer. The user operates the device from a display unit mounted on the dashboard.

Siddharth said: "We are pleased to say that we won this year's challenge, having won it for the second time in a row (we previously won in 2015).

"We researched existing solutions available on the market and after considering the advantages and disadvantages of each one in the context of the brief, decided on a vibration-based approach.

"One of the key disadvantages to any commercial solution was the need for regular recalibration by the manufacturer. We were keen to avoid this as it would be impractical in a humanitarian aid context and felt our solution needed to be easy to install and repair."

Martin McCann, RedR UK Chief Executive, said: "NGOs often work off-road in challenging terrain and are reliant on vehicle fleets for day-to-day operations. The consequences of overloaded vehicles include higher fuel consumption, serious risk of damage to the vehicle, and increased danger of crash incidents. This can leave vehicles unavailable for weeks at a time, causing implications for the provision of relief services and for the safety of agency staff.

"RedR is pleased to be working with the IET in the Global Challenge and we are impressed with the quality of the projects submitted for the competition. In particular, my congratulations go to the 'Good Vibrations' team who designed the winning project."

Nick Winser, IET President, added: "This competition is all about giving young engineers a platform to highlight their innovations. By shining a light on a particular problem we've found that engineers think outside of the box and come up with innovative solutions.

"Previous winners of this challenge have gone on to see their innovations becoming reality, so this is a great way to make a difference and solve a real world challenge."

→ www.theiet.org/global-challenge
www.redr.org.uk

Credit: Cljf83

An 'intelligent' system to prevent bridge strikes by tall trucks

Bridge strikes by over-height vehicles could be made a thing of the past thanks to a new cost-effective detection system developed by Cambridge researchers.

Using computer vision technology, the system is able to detect – in advance – whether approaching vehicles are at risk of hitting a bridge. One calibrated camera per direction is mounted on the side of the road at the maximum allowed bridge height looking across all lanes of traffic. From there, it uses the over-height plane concept (shown as a line in the camera view) to find over-height vehicles.

A tall truck hits a bridge every four-and-a-half hours in the UK, causing traffic chaos and costing thousands of pounds in repair and maintenance. In the UK alone, there are more than 10,000 railway bridges crossing over roadways. Of these, 3,400 are considered to be 'at risk', due to a low clearance height. The average cost per bridge strike ranges from £5,000 to £25,000.

Engineering PhD alumnus Dr Bella Nguyen investigated means of detecting and preventing bridge strikes, and the results were the subject of a recent study for Transport for London (TfL), published in the *Journal of Computing in Civil Engineering*.

The paper titled *Optimized Parameters for Over-Height Vehicle Detection under Variable Weather Conditions*, has since been selected by the Construction Institute to receive the 2018 John O. Bickel Award.

The new system is paired with an LED display unit downstream to warn drivers of the upcoming low bridge and suggesting they take the nearest road exit. If the driver continues and hits the bridge, accelerometers on the bridge structure will instruct the system to keep a copy of the most recent video feed as evidence and extract from it number plate information. The collision report containing all this information is then sent to the relevant authorities for action.

Dr Ioannis Brilakis, Laing O'Rourke Reader in Construction Engineering, said the new vision-based detection system is the result of a joint project with TfL, with partial funding secured from the Centre for Smart Infrastructure and Construction (CSIC).

"Bridge collisions involving over-height vehicles lead to traffic delays, congestion and, in extreme cases, can derail trains and cause bridges to collapse," said Dr Brilakis. "What we have created at the Construction Information Technology (CIT) Laboratory, is an autonomous system that bridge owners can use to reduce the number of strikes and charge offenders when damage is caused. The new system matches the performance of its predecessors at a fraction of the cost."

"Using computer vision, we are now able to detect over-height vehicles and capture number plates from the same camera feed in variable weather conditions," said Dr Nguyen. "We mount the camera at the clearance height to detect vehicles that exceed it and remove any false detections caused by environmental factors. This allows us to provide a personalised warning for drivers, enabling them to take the nearest exit and avoid hitting the bridge."

Watch how the detection system works:
youtu.be/pMMpmUaXhRM
www.eng.cam.ac.uk/profiles/ib340
www.eng.cam.ac.uk/profiles/bbn20
http://cit.eng.cam.ac.uk/
www-smartinfrastructure.eng.cam.ac.uk

Re-engineering the healthcare system

Credit: pixabay

A new roadmap has been unveiled for engineering and physical science researchers to optimise opportunities for using digital health in remote monitoring and self-management of disease.

The roadmap, which was developed through workshops organised by the EPSRC-funded FAST Healthcare Networks*Plus*, identifies four areas where such research can play a central part:

- **Generic continuous monitoring from a diversity of information sources.** This includes sensor technologies and data management and extraction which makes use of engineering in the form of data-sharing platforms, analytic tools and machine learning
- **Recovery monitoring.** Optimising the patient's recovery process based on real data acquired by using decision assistance systems to measure a small number of specific indicators continuously
- **Early diagnosis.** Making an early diagnosis of a condition from multiple data sources, making use of machine learning, data sharing and multi-data analytics, as well as decision assistance systems
- **New patient access routes.** Identifying new ways for patients to access the NHS by making use of virtual reality systems, the internet and mobile apps.

It has been developed in response to rapid changes in healthcare delivery as the NHS strives to meet the needs of an ageing population; witnesses an increase in the number of people with long-term chronic conditions such as diabetes or heart disease; and recognises the benefits of patients being able to self-manage their own care.

It is anticipated that digital technologies will lead to a radical transformation of the NHS, with changes in care pathways, as well as the transfer of care from hospital settings to the community and even to patients' own homes, meaning more care will be provided outside the traditional healthcare settings.

Professor Andrew Flewitt is the Principal Investigator of the EPSRC FAST Healthcare Networks*Plus* and Professor of Electronic Engineering at the University of Cambridge.

"Digitally enabled changes in patient pathways will require considerable re-engineering as well as re-training of healthcare staff. It will also increasingly blur the boundaries between wellness, prevention and care management," he said.

"In response to this, the FAST Healthcare Networks*Plus* held its second Roadmapping Workshop on the subject of 'Digital Health for Remote Monitoring and Self-Management' resulting in a user-focused roadmap which aligns closely with the 'Internet of Things' (IoT). It also relies on engineering and physical sciences research, leading to improvements in the diagnosis, monitoring and treatment pathways for care at home, particularly across multiple clinical conditions."

> The user-focused roadmap relies on engineering and physical sciences research, leading to improvements in the diagnosis, monitoring and treatment pathways for care at home, particularly across multiple clinical conditions.
>
> Professor Andrew Flewitt

www.fast-healthcare.org.uk/meet-the-team/prof-andrew-flewitt
www.fast-healthcare.org.uk/digital-health-workshop

ALUMNI UPDATE

Becoming Wind Pioneers

Alumnus Jerry Randall is a specialist wind engineer with a wealth of experience working on wind farm projects across South and Southeast Asia.

Jerry recounts his path from Cambridge to starting his company Wind Pioneers.

My first exposure to the wind industry was a summer internship with a wind turbine blade factory on the Isle of Wight following my first year at Cambridge. I was thrown in the deep end, helping refine the manufacturing process for 40m-long composite blades. It showed me a young, vibrant industry full of serious technical challenges to solve, and the satisfaction of being at the coalface of creating a sustainable future for the planet.

After graduating with an aerospace specialisation, I spent a year in Beijing designing blades for the largest Chinese manufacturer of wind turbines. That year cemented my interest in wind and also taught me that I thoroughly enjoyed living and working overseas. I subsequently joined a renewables consultancy, spending four years split between India and Bangkok, undertaking project development work for new wind farm sites across Asia.

One day, standing atop of a proposed wind site in Southeast Asia, it dawned on me that there was a real need for improved engineering approaches for finding great new wind farm sites. The site was beautiful and had everything you would want for a wind project. My experience as a wind engineer was telling me this was a great site, but everything within that experience could easily have been distilled into an analytical process. While the design of wind turbines has become highly sophisticated, the identification of sites is still relatively basic and it was patently obvious to me that more sophisticated approaches were needed.

In addition to observing a technical need for smarter engineering of wind sites, I was also witnessing first hand an entrepreneurial opportunity.

Within the last few years, onshore wind has become the outright cheapest form of new energy in the majority of markets. For fast-growing emerging economies, wind offers an opportunity to bring cheap energy onto the grid at a pace that can keep up with increasing demands. Wind is entering markets, from Myanmar to Saudi Arabia; it couldn't have been dreamt of just a few years ago.

In brand new markets, there is an inherent shortage of local, experienced wind engineers. It was clear that wind developers in these new markets needed more than smarter engineering; they needed access to affordable and flexible engineering that the incumbent European consultancies weren't able to provide.

So in mid-2016, I moved back to Bangalore to found Wind Pioneers with the aim of addressing both the technical and commercial demands of the industry. We have bootstrapped ourselves, and a year and a half after we formed, we are now consulting for wind farm developers in a dozen markets across Asia Pacific, helping find and design the next generation of wind farm sites.

Being based in India suits the company perfectly. Beyond giving me year-round sunshine, having low overheads means we can compete in any market globally, no matter how price sensitive. It also allows us to invest much more heavily in research and development. There's no better city in the world than Bangalore for access to great value engineers. Our team is small but our ambitions are big – we want to develop the most powerful approaches in the industry for finding and designing new wind farms. It's a very achievable aim as we already lead our competitors in key aspects of the site development process.

I have found an industry that suits me perfectly: it's new, dynamic and highly internationalised. The industry is growing rapidly, and growth always brings opportunities. Lastly, there is tangible satisfaction being associated with an industry that is at the battlefront of the crucial fight to create a sustainable world.

The multidisciplinary and rigorous nature of the Cambridge engineering course has without doubt greatly helped me in my career to date. I'm thankful for the first year structures course where I sat in meetings discussing the design of pile foundations for turbines, and before I started Wind Pioneers, I sat down, dusted off the rudimentary C++ I had learned at the Department, and tested some ideas I had about characterising terrain at prospective sites.

Last year, we took two interns from the Department who did some very valuable work for us. We're very much hoping to make this into a regular setup and look forward to students from the Department helping us with our pioneering wind work, as we work towards our goal of creating better-engineered wind farm sites around the globe.

www.wind-pioneers.com

PHILANTHROPY UPDATE

Engineering future scientists

Children are often asked: "What do you want to be when you grow up?" It's a difficult question to answer. And if a child has not been exposed to a broad range of career opportunities, their choice of responses may be limited.

The Department of Engineering is running a pilot programme, 'Inspiring 21st Century Engineers', whereby children in Year Nine are invited to take part in a series of four masterclasses, spaced four weeks apart.

During each session, the children are introduced to a particular aspect of engineering, before participating in a hands-on activity that brings the information to life, supervised by staff and students.

Mirroring other outreach programmes held by the Department, each child is invited to bring a parent or other interested adult with them.

"There is evidence that exposure to science through parents and other close adults helps pique children's interest in the subject," says Maria Kettle, Outreach Officer at the Department. "Follow-up discussion motivates the students further, and the parents' insights will add to their enthusiasm."

Two masterclasses have already taken place. Engineers from SDC Builders Ltd, working on campus, were eager to assist in the programme, and the first two sessions had their builders and Cambridge academics and students helping the children to make their own concrete and learning all about its properties. Participants were able to mix, mould and stamp their concrete, and later test it.

The students visited the site of the new Structures Laboratory, where they saw concrete in action. Partially completed floor slabs were visible, alongside the columns that will support earthquake bearings that will isolate the new strong floor from the sensitive equipment in the nearby Graphene Centre building. Perhaps, one day, some of the students will experiment in that very laboratory.

"It really is a fun way for children to be exposed to engineering," says Maria. "The programme will encourage aspirations to study Engineering at university, and particularly in children who might not have thought of it. It's also a great way for students to learn about communicating their own knowledge and passion to non-experts."

The masterclasses are currently targeted at schools in East Anglia and Norfolk.

The programme is enabled by the generous support of Cambridge alumnus, Dr Brian Thompson (Peterhouse 1956), who is eager to ensure that children from diverse backgrounds are inspired by the fascinating world of engineering.

"My own career in engineering was extremely satisfying," says Brian. "I wanted to support these masterclasses so that children understand that there is something truly fulfilling about designing and making things, and it is imperative that we ensure more young people and their families regard engineering as an important part of the nation's strength. I'm particularly motivated to encourage more children from less advantaged backgrounds to have the opportunity to access the same kind of technical education that I did."

www.eng.cam.ac.uk/events-and-outreach
www.philanthropy.cam.ac.uk

Professor Ken Wallace 1944 – 2018

The Department announces with deep sadness the death of Emeritus Professor of Engineering Design Kenneth Wallace. It is so typical of Ken that he wrote his own obituary to make it easier for all of us after his passing. The words below were written by Ken before he died on 3 March 2018.

Ken Wallace was born in Newcastle-upon-Tyne towards the end of World War II, on 21 March 1944, to Joan and Gordon Wallace.

It was at Brentwood that he joined the RAF cadets and was introduced to flying, first in gliders and subsequently in power aircraft.

After leaving school in 1962, he moved to Derby as a University Apprentice with Rolls-Royce Aero Engines. However, the opportunity arose to spend a year working for Flugzeug-Union-Süd in Munich and Rolls-Royce agreed to release him for a year. This was a very formative year for Ken and becoming fluent in German proved to be extremely valuable many years later when he moved to Cambridge.

During his first summer vacation in 1965, he met, and fell instantly in love with, Annette Fothergill, and on Ken's 22nd birthday in 1966, he asked her to marry him.

Ken had a desire to teach in higher education, but this proved challenging with no PhD, no teaching qualifications and no teaching experience. In August 1971, he was appointed to a lectureship at Oxford Polytechnic. He continued to teach there until 1977, during which time his two daughters, Harriet (1973) and Elizabeth (1975) were born.

In 1977, he saw an advertisement for a Lectureship in Engineering Design at the University of Cambridge. His appointment at Cambridge started on 1 January 1978 and he was initially tasked in updating the design teaching in the Department with the aim of bringing it up to world-class standards. He was elected a Fellow of Selwyn College on the same date.

He moved into the fledgling field of design research in the early 1980s, starting by translating and editing the classic German text 'Engineering Design by Pahl & Beitz'. The first English edition was published in 1984 and to his considerable surprise it became the most frequently referenced text in the field of engineering design – a position it holds to this day. Its timely translation underpinned design teaching and research at Cambridge and at many universities around the world.

By the end of the decade, the Engineering Department's reputation in design research was sufficiently established to apply, along with Professors David Newland and Michael Ashby, to the Engineering and Physical Sciences Research Council (EPSRC) for a grant to set up an Engineering Design Centre (EDC) in the Engineering Department. The EDC was established on 1 January 1991, with Ken as its first Director. In 1997, he handed over the Directorship of the EDC to Professor John Clarkson and under John's leadership the EDC has grown steadily and currently has around 65 research staff and students.

In 1999, Ken was diagnosed with prostate cancer and this prompted a rebalancing of his work responsibilities. The opportunity arose to set up a new research group within the EDC and in 1998 he became a Co-Director of the BAE SYSTEMS/Rolls-Royce University Technology Partnership (UTP) for Design, overseeing the research into Knowledge Management undertaken at Cambridge. One of the most successful outcomes of the UTP's research was the delivery to Rolls-Royce of the design rationale capture software, called DRed. This is now used throughout Rolls-Royce to capture the design decision-making process and to communicate between designers working in different companies and countries.

He retired from the University in 2007, 30 years after taking up his appointment. He had four grandchildren, Ben, Orla, William and Alfred. In April 2017, he celebrated his Golden Wedding Anniversary with Annette and his family.

In September 2017, Ken was diagnosed with the rare and aggressive cancer – Anaplastic Thyroid Cancer. He received intensive radiotherapy, the best possible care from Addenbrooke's hospital and he had great determination to beat it.

Professor John Clarkson was a friend and colleague of Ken for many years and he contributed the following words.

Ken's work in the EDC transformed engineering design research, bringing a new level of rigour and relevance to the topic. Yet he will also be remembered for the way in which he worked with his postgraduate and postdoctoral researchers, with great understanding and encouragement, developing the person as well as the subject. Many will remember his eye for detail, with changes suggested in such a way they were always welcomed. Ken remained actively in touch with all of his researchers, continuing to be interested in their personal and professional progress for many years after their departure from the EDC.

Ken also gave so much to the international design research community, not only through his own efforts, but also through encouraging the efforts of others. It was a characteristic of Ken that he was always far more interested in building a thriving community than in furthering his own ambitions and it is the way in which he gave, with wisdom delivered unselfishly and with such modest good humour, that ensures that so many people held him in such high regard. He made an exceptional contribution to the community accompanied by his unrelenting passion for engineering design.

He will be greatly missed by all who knew him.

An internship at Siemens allowed Kim to get ‘hands on’ with smart data

↑ Kim (centre) during a training course on how to use the Siemens Fastflex processor modules

Engineering undergraduate Kim Barker (Emmanuel College) recently completed a 12-week internship at Siemens. Here she details her experience.

Hi Kim, what were the highlights of your internship?

One of my favourite projects I worked on was the Business Improvement Project. Working together with a team of other undergraduates, apprentices and graduates, the aim of this project was to generate ideas for the future of the Siemens CIS (communication and information systems) business. We competed with other teams in presenting a business case for our idea to senior management.

Our team proposed a new future for the SCADA (data acquisition) system that also analysed this data to produce fresh insights and subsequent actions. This involved the turning of Big Data into Smart Data to enable predictive maintenance to reduce delays on the rail network. It is exciting to think that our solution could be implemented into live projects in the near future.

There were also lots of opportunities to get involved in things outside of work too, such as team building events which have helped me to form better relationships with colleagues. I also joined the Equality Diversity and Inclusion Committee to run events, and participated in the Siemens Charity Mind Walk.

How has the internship benefitted you?

I have had the opportunity to move around several areas of the business and get involved with a few different projects at Siemens. I gained valuable experience working for a big company with a diverse range of people from across the business. It gave me a good insight into future career prospects, as I would love a career in engineering working at a big international company such as Siemens on exciting large-scale projects.

If you are an employer interested in discussing summer internship opportunities for Cambridge undergraduates, please email Vicky Houghton, Industrial Placements Co-ordinator, at placements-coordinator@eng.cam.ac.uk

www.placements.eng.cam.ac.uk

Honours, awards and prizes

Alumna receives Gold Medal

Alumna Jo da Silva, Director of Arup's International Development Group and Arup Fellow, has been awarded The Institution of Structural Engineers' 2017 Gold Medal.

The Medal has been awarded to recognise the outstanding leadership she has provided as both a structural and humanitarian engineer and for her distinguished and cross-sectoral work on urban resilience.

Professors elected as Fellows

Congratulations to Professors Julian Allwood (left) and Richard Prager (right) on being elected Fellows of the Royal Academy of Engineering.

Our congratulations also go to Tony Purnell, Royal Academy of Engineering Visiting Professor here at the Department and alumni Dr Caroline Hargrove, Technical Director, McLaren Applied Technologies and Dr Eben Upton, co-founder and Chief Executive Officer at Raspberry Pi, who have also been elected Fellows of the Royal Academy of Engineering.

Leverhulme Early Career Fellowships announced

Prestigious Leverhulme Early Career Fellowships have been awarded to researcher Dr Volker Deringer (left) and alumnus Dr Ubaid Ali Qadri.

The aim of the Fellowship is to provide career development opportunities for those who are at an early stage of their academic careers, but already have a proven record of undertaking research.

Professor elected to Chinese Academy of Engineering

Professor Dame Ann Dowling has been elected as a member of the Chinese Academy of Engineering (CAE).

Dame Ann has been elected in recognition of her contributions to mechanical and aeronautical engineering and the promotion of China-UK engineering collaborations.

Professor joins the Department

George Malliaras has been appointed as the Prince Philip Professor of Technology. The University established the Professorship in recognition of the contribution made by HRH Prince Philip as Chancellor of the University.

Professor Malliaras' group within the Electrical Engineering Division, is interested in bioelectronics. Research themes include the design and validation of implantable devices to interface with the brain, with the aim of understanding and treating neurological disorders. They also include the realisation of electronic devices and circuits that mimic some of the computational features of the brain.

New Head of the Institute for Manufacturing

Professor Tim Minshall, the inaugural Dr John C Taylor Professor of Innovation, has become the new Head of the Institute for Manufacturing (IfM).

Professor Minshall has taken over from Professor Andy Neely, who was appointed the University of Cambridge's Pro-Vice-Chancellor for Business and Enterprise.

President's Prize awarded

Alumna Cara Cooper recieved The Institute of Physics and Engineering in Medicine President's Prize for best oral presentation.

Cara is working with Professor John Clarkson's group on healthcare design. Her prize-winning presentation was on her paper titled Hear Glue Ear: *Horizontal Innovation to provide hearing for children with Glue Ear.*

Could we build a Blade Runner-style 'replicant'?

Credit: Henrique Costa

Could replicants ever be a reality? In this article from *The Conversation*, Dr Fumiya Iida, Lecturer in Mechatronics, discusses what it would take to make a truly lifelike robot.

The *Blade Runner* sequel returns us to a world where sophisticated androids made with organic body parts can match the strength and emotions of their human creators. As someone who builds biologically inspired robots, I'm interested in whether our own technology will ever come close to matching the 'replicants' of *Blade Runner 2049*.

The reality is that we're a very long way from building robots with human-like abilities. But advances in so-called soft robotics show a promising way forward for technology that could be a new basis for the androids of the future.

From a scientific point of view, the real challenge is replicating the complexity of the human body. Each one of us is made up of millions and millions of cells, and we have no clue how we can build such a complex machine that is indistinguishable from us humans. The most complex machines today, for example the world's largest airliner, the Airbus A380, are composed of millions of parts. But in order to match the complexity level of humans, we would need to scale this complexity up about a million times.

There are currently three different ways that engineering is making the border between humans and robots more ambiguous. Unfortunately, these approaches are only starting points, and are not yet even close to the world of *Blade Runner.*

There are human-like robots built from scratch by assembling artificial sensors, motors and computers to resemble the human body and motion. However, extending the current human-like robot would not bring *Blade Runner*-style androids closer to humans, because every artificial component, such as sensors and motors, are still hopelessly primitive compared to their biological counterparts.

There is also cyborg technology, where the human body is enhanced with machines such as robotic limbs, wearable and implantable devices. This technology is similarly very far away from matching our own body parts.

Finally, there is the technology of genetic manipulation, where an organism's genetic code is altered to modify that organism's body. Although we have been able to identify and manipulate individual genes, we still have a limited understanding of how an entire human emerges from genetic code. As such, we don't know the degree to which we can actually programme code to design everything we wish.

Soft robotics: a way forward?

But we might be able to move robotics closer to the world of *Blade Runner* by pursuing other technologies, and in particular by turning to nature for inspiration. The field of soft robotics is a good example.

This technology is inspired by the fact that 90% of the human body is made from soft substances such as skin, hair and tissues. This is because most of the fundamental functions in our body rely on soft parts that can change shape, from the heart and lungs pumping fluid around our body to the eye lenses generating signals from their movement. Cells even change shape to trigger division, self-healing and, ultimately, the evolution of the body.

The softness of our bodies is the origin of all their functionality needed to stay alive. So being able to build soft machines would at least bring us a step closer to the robotic world of *Blade Runner*. Some of the recent technological advances include artificial hearts made out of soft functional materials that are pumping fluid through deformation. And 'epidermal electronics' has enabled us to tattoo electronic circuits onto our biological skins.

Softness is the keyword that brings humans and technologies closer together. Sensors, motors and computers are all of a sudden integrated into human bodies once they became soft, and the border between us and external devices becomes ambiguous, just like soft contact lenses. Nevertheless, the hardest challenge is how to make individual parts of a soft robot body physically adaptable by self-healing, growing and differentiating.

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