DEPARTMENT OF ENGINEERING

# NEWS

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## Inspiring research through industrial collaboration

## The Making of a Smart Tunnel: measuring tunnelling history for the first time

## Super-fast and super-green: Cambridge unveils pioneering high-performance computer

UNIVERSITY OF CAMBRIDGE

## In this issue



**Cover photo: PhD student Jenna Shapiro who is involved in an interdisciplinary project between the Department of Engineering and the National Institutes of Health in the United States.**


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**My five-year term of office as Head of Department at Engineering** will draw to its scheduled close in October, when Professor David Cardwell will step up to the role. I very much hope that he enjoys his time as Head as much as I have.

The Department of Engineering at Cambridge is unusual, because it is an integrated department covering all of the engineering disciplines. Elsewhere, heads of department generally lead a team of academics focussed within their own field such as civil, electrical or mechanical engineering. In Cambridge, I have had a wonderful opportunity to learn from, and work with, colleagues of the highest calibre across the full range of engineering disciplines. This experience has underlined the importance of engineers working together to address the great challenges facing our society, the value of our general engineering teaching, and our capacity to shape the future. I have enjoyed recruiting over 35 new members of academic staff, seeing undergraduate applications for engineering soar by nearly 40% and the number of graduate students grow by 250.

School pupils, parents, teachers, businesses and politicians are now beginning to see clearly that engineering is essential, exciting and a real force for good in the world. The challenge is to keep momentum, meet demand and maintain our world-class standards. This is going to take more investment and more hard work.

Having seen the dedication and energy of our academics and students, I have no doubt that engineering at Cambridge will continue to excel. I will carry on flying the flag for engineering as a whole when I become the President of the Royal Academy of Engineering later this year. I will also press ahead with my own research in aeroacoustics in the Department. I feel very privileged to have gained high-level views from the best minds about where engineering is heading, while also being able to have the joy of undertaking my own technical research and, of course, teaching. Most of all I will remember the enthusiasm and support of colleagues across the Department and University, and our many external collaborators, who have made my time as Head so enjoyable.

*Professor Dame Ann Dowling*

**Professor Dame Ann Dowling, Head of the Department of Engineering**

**Our alumni, staff and students now stay connected in a number of ways using social media on sites such as Twitter, YouTube, Facebook and Flickr (urls below). We also have a dedicated LinkedIn group for alumni of the Department which we would encourage you to join.**
**https://twitter.com/Cambridge_Eng**
**http://www.linkedin.com/groups?gid=127740**
**http://www.flickr.com/photos/cambridgeuniversity-engineering/**
**https://www.facebook.com/DepartmentOfEngineeringUniversityOfCambridge**
**http://www.youtube.com/user/EngineeringCambridge**
**http://www.eng.cam.ac.uk/**

**We are also delighted to tell you that this newsletter, which is currently sent out to nearly 18,000 alumni worldwide, can now be emailed to you as a web link rather than a traditional paper copy. If you would prefer to receive your newsletter in this way please contact engineering@admin.cam.ac.uk**

**An integrated engineering department founded on core strengths spanning all engineering disciplines and also cross-connected by an integrated undergraduate course and four strategic research themes:**
- **Energy, transport and urban infrastructure**
- **Uncertainty, risk and resilience**
- **Bioengineering**
- **Inspiring research through industrial collaboration.**

## The Making of a Smart Tunnel: measuring tunnelling history for the first time

**The Cambridge Centre for Smart Infrastructure and Construction (CSIC)'s instrumentation is set to demonstrate the behaviour of a cast iron tunnel at a scale that has never been done before using ground-breaking technologies.**

**Smart tunnel with monitoring devices**

CSIC, an innovation and knowledge centre funded by EPSRC and the Technology Strategy Board to develop and commercialise emerging technologies, is beginning to see the fruits of its labour with a number of innovative research and development projects underway. CSIC's team of PhD students and researchers have been installing innovative monitoring devices in a 30 metre stretch of a 100-year-old, disused tunnel, deep in London's underground – transforming it into a 'smart tunnel', capable of monitoring stress levels in real time and seeing how they change during excavation.

Late last year, Crossrail started excavating its gigantic 12m diameter tunnel directly beneath CSIC's 'smart tunnel'.

"This is not only incredibly exciting for the CSIC team," remarked Dr Jennifer Schooling, CSIC's Director, "it is also a first on a number of counts. It is the first time so many of our revolutionary devices have been used to monitor the movement of an existing tunnel. It will also mean that we will see what effect such a large-scale excavation will have on a cast iron tunnel for the first time, almost in real time."

Seventy percent of London's ageing, Victorian underground tunnels are made of cast iron. Using such instrumentation is an efficient and economical way of monitoring miles of tunnels such as those in London. This project will use ground-breaking technologies to show the behaviour of cast iron tunnels to a scale that has never been done before and give information on how further technologies like the ones used by CSIC can be used in other similar tunnels.

***"It is the first time so many of our revolutionary devices have been used to monitor the movement of an existing tunnel. It will also mean that we will see what effect such a large-scale excavation will have on a cast iron tunnel for the first time, almost in real time."***

**Jennifer Schooling**
**CSIC's Director**

**www-smartinfrastructure.eng.cam.ac.uk**

## Institution of Civil Engineers honour for Dr Abir Al-Tabbaa

**Congratulations to Dr Abir Al-Tabbaa of the Department's Geotechnical and Environmental Research Group who has been elected Fellow of the Institution of Civil Engineers (ICE).**

Fellow is the highest grade of membership of ICE and is awarded to members who are or have been engaged in a role of significant responsibility in the promotion, planning, design, construction, maintenance or management of important engineering work.

Dr Al-Tabbaa's main research interests are in sustainable construction materials, ground improvement, land remediation and carbon capture and storage. She is involved in the Department of Engineering's large multi-institutional and multi-disciplinary EPSRC-funded project Materials for Life, developing self-healing cement-based construction materials. She is also Deputy Director of the Department's newly established Centre for Doctoral Training in Future Infrastructure and Built Environment.

Dr Al-Tabbaa has undertaken fundamental and applied research that has advanced the body of engineering knowledge in her areas of research expertise and has had a significant role in the development and delivery of civil engineering education and training.

**www.ice.org.uk**

## GloverFest celebrates the work of Professor Keith Glover

**A two-day workshop was held to mark the contributions of former Head of Department Professor Keith Glover to the control field on the occasion of his retirement.**

GloverFest – officially called the 2nd Workshop on Control of Uncertain Systems: Modelling, Approximation, and Design – took place in September last year and included an opening reception at Clare College, a banquet at Trinity College and a closing reception at Sidney Sussex.

The list of speakers included many of his collaborators and former PhD students, who are very prominent researchers in the control field. Contributors came from Australia and the US and Canada as well as from most of the key control groups in Europe. The workshop was sponsored by MathWorks, whose president and co-founder Jack Little also attended.

**Photographs of the event are available to view on the Department's Flickr site: www.flickr.com/photos/cambridgeuniversity-engineering/sets/72157637908585424**

## Mike Sharman

**Mike Sharman, a pioneering course director in manufacturing at the Department of Engineering, University of Cambridge, has died, aged 80.**

Mike read Engineering at St John's College, Cambridge. Always more keen on practical action than on abstract theorizing, he went to work for the famous de Havilland aircraft company in Hatfield.

An enthusiastic and engaging communicator, Mike moved to become a lecturer at the highly-regarded Hatfield Polytechnic before being recruited back to Cambridge by John Reddaway to run a radical new postgraduate course, initially known as the Reddaway Plan.

Reddaway had returned to join the staff of the Engineering Department after a period in industry. Encouraged by John Baker and Will Hawthorne, he outlined, with David Marples, a more engaging and demanding way to introduce graduates into industrial life rather than the then commonplace 'sitting by Nelly' – learning from experienced workers.

After a couple of trial runs in long vacations the 'Advanced Course in Production Methods and Management' (ACPMM) was launched in 1966 with 12 handpicked graduates as 'guinea pigs', support from leading manufacturing companies of the time, and Mike Sharman as the Course Director.

This pioneering role fitted Mike like a glove and he immediately took full ownership of the initiative. His energy, enthusiasm and knowledge of practical engineering as well as the theoretical context, inspired and excited the 'guinea pigs' who loved the course, as have successive generations of students.

Under Mike Sharman's vigorous and tenacious leadership the course flourished, enjoying support from major companies as well as the Engineering and Physical Sciences Research Council (EPSRC) and the Department of Trade and Industry (DTI) at a time when manufacturing was much less fashionable.

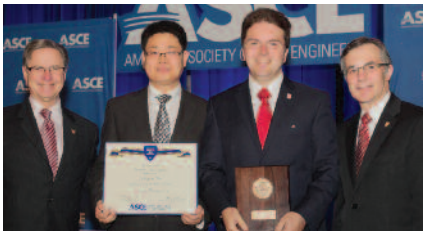
At its peak the course was able to take more than 50 students a year and became the Advanced Course in Design, Manufacture and Management (ACDMM). Today, the course is the MPhil in Industrial Systems, Manufacturing and Management (ISMM) and its 40 places are regularly five times oversubscribed – though Mike always wished to see more bursaries for UK students.

Mike was a Fellow of Wolfson College from 1982 to 1996 and an Emeritus Fellow from 1996 to 2013. He was awarded an MBE in 1994 for his significant contribution to Engineering Education.

Unfailingly generous, knowledgeable and engaged, Mike substantially influenced the lives of many of us who were taught by him. He died peacefully and is survived by his three daughters and his wife, Margaret.

## US award for Department lecturer

**Dr Ioannis Brilakis, Laing O'Rourke Lecturer of Construction Engineering in the Department of Engineering, has been honoured by the American Society of Civil Engineers (ASCE).**



DAVID HATHCOX/ASCE

**Presentation of Collingwood Prize to Ioannis Brilakis (third from left) and Zhenhua Zhu by Greg DiLoreto and Patrick J. Natale**

Ioannis and his former students at the Georgia Institute of Technology, Zhenhua Zhu (now of Concordia University, Canada) and Stephanie German(now of EPFL, Switzerland), were awarded the 2013 Collingwood Prize from ASCE for their paper titled "Visual Pattern Recognition Models for Remote Sensing of Civil Infrastructure". In selecting this paper, the committee particularly noted its contribution to engineering knowledge.

This paper stemmed out of Ioannis' CAREER Award from the US National Science Foundation. It outlines his fundamental theory on how to create recognition models for civil infrastructure elements, such as columns, beams, walls, slabs, decks, etc. followed by example applications that have proven successful. The paper essentially formalises the process of creating new Visual Pattern Recognition (VPR) models to simplify the steps needed to create each mathematical description and provide a set of common tools necessary for this purpose. This will automate the transformation of infrastructures' 3D surfaces into information-rich, 3D element models with the help of machine vision.

**http://cit.eng.cam.ac.uk/lab-director/lab-director**

## Cheesy fun for Dyson outreach event

**Melted cheese and boomerangs were the order of the day when students from a Cambridge secondary school visited the Department to see demonstrations of cutting-edge Engineering projects.**

PERRY HASTINGS

Standing (from left) Alex Robinson, Tom Dyson, Fraser Atkins, Wai-chuen Cheung; kneeling Will Vernon (left) and James Blood

The current recipients of James Dyson Foundation Undergraduate Bursaries held an open morning for year 10 students from Parkside School. As part of their award, the final year Engineering students are expected to present their projects to other young people in a manner which will inform, educate and inspire them. Invited guests included some of the academics involved in supervising the projects, along with Tom Dyson, brother of James Dyson the inventor, industrial designer and founder of the Dyson company and the charitable James Dyson Foundation.

The Bursaries were established in 2011 to support fourth-year undergraduate student projects in Engineering Problem Solving and Design. The awards are targeted at projects which offer excellent opportunities for outreach work in schools and include individual bursaries of up to £1,000.

> ***"This has really changed my perception of engineering – I hadn't realised what a wide ranging subject it was, or how creative an engineer can be."***
> **Natalia Adamson, year 10 student**

Students Wai-chuen Cheung, Fraser Atkins, Will Vernon, Alex Robinson and James Blood made presentations to the school students which involved demonstrating how wings work, projectile motion, solar-powered cards and 3D printing. Paul Mallaband presented his project on Arduino electronics separately during an off-site school visit. Demonstrations and hands-on practical sessions saw the Parkside students simulating the effects of a 3D printer by using syringes full of melted cheese and tortilla wraps, building their own solar powered vehicles and mastering the tricky art of origami to create their own paper boomerangs.

Will Vernon commented: "I really enjoyed interacting with the students. It was great fun to hear their ideas and thoughts on the lecture subjects. I found it quite tricky to present to them on a new topic, and to explain the relevant engineering principles in a simple and understandable way. I was very impressed by how some of the teams approached the 3D printing task by coming up with very different and sometimes ingenious ways to build the tallest tower that none of us had thought of."

Alex Robinson, a member of the Cambridge University Eco Race team, showed how to build a basic car which could be powered by a solar cell and was impressed by how engaged the young students were with the task. He said: "I was impressed with the cars produced – the students obviously thought through the design, with some choosing to make three-wheeled versions to save weight, or even a four-wheel-drive version using two kits. I was surprised how involved the students were with the activity, as they were all very keen to get a working vehicle by the end, and clearly enjoyed testing them. Hopefully they could also see the links to real-world engineering design challenges."

The morning session was summed up by Fraser Atkins who concluded: "Seeing the enthusiasm of the students was incredibly rewarding and I sincerely hope that it has led to some of them considering engineering in the future."

Parkside student Natalia Adamson was in full agreement. She said: "This has really changed my perception of engineering – I hadn't realised what a wide ranging subject it was, or how creative an engineer can be."

**www.jamesdysonfoundation.co.uk**

## Cambridge professor elected Fellow of Royal Academy of Engineering

**US-born and Japanese-educated, Kenichi Soga has been Professor of Civil Engineering in the Department since 2007.**

Professor Soga is a world authority on soil behaviour and geotechnical engineering, and his work has broad applications in civil engineering projects and in areas such as disaster prevention.

His research work looks at geomechanical processes from the monitoring and instrumentation of civil engineering projects to the simulation of ground deformation and submarine landslides. He is on the executive board of the Cambridge Centre for Smart Infrastructure and Construction, and some of his research covers the technology of remote monitoring and wireless sensors in collecting data on civil engineering infrastructure. He is also involved in several research ideas in environmental geotechnics, such as the extension of geothermal energy from individual buildings to city-wide schemes.

The Academy announced the election of its new Fellows at the AGM. Election to the Academy is by invitation only, with up to 60 Fellows elected each year from nominations made by existing Fellows.

Sir John Parker GBE FREng, President of the Royal Academy of Engineering, said: "We warmly welcome our new Fellows to the Academy. With their expertise, knowledge and vision we will continue to strengthen our ambition of providing authoritative, impartial, and expert engineering advice to government and to develop the Academy's growing impact and influence on a global stage."

**www.raeng.org.uk**

# Open-source through the lens of a microscope

**A low-cost professional microscope based on open-source technologies has been developed by a group of engineers in the Department.**


Members of the OpenLab tools initiative

Now seeking active support from sponsors, the project is part of the OpenLabTools initiative, a new cross departmental initiative to develop open-source instruments for education and research that will remain in the public domain. Academics from five departments, across three schools, are involved in the programme. The project is aimed at providing a forum and knowledge centre for the development of low-cost and open-access scientific tools. It will enable research centres all over the world to do work even with a tiny budget. This may be a spur to education and scientific development in countries with limited resources.

The microscope prototype will cost around US$800, whereas conventional microscopes cost between US$15,000 and US$80,000. It will be modular and simple to replicate, improve and adapt to different research purposes, as the instructions will be made available online. The microscope's electronics are controlled by Raspberry Pi, the US$25 computer launched in 2012 by engineers at the Raspberry Pi Foundation. Originally designed for educational purposes, this computer is the size of a smartphone and has proven to be suitable for a variety of uses, including gaming and research.

"We are not trying to develop a new cutting-edge technology," says Alexandre Kabla, project supervisor. "We want to use tools already available on the market to design new and flexible products. Our aim is to share results and build a community that will progressively make these instruments better."

The limited market for scientific instruments means that traditional laboratory equipment could be expensive and therefore out of the reach of university teaching laboratories and research institutions, in particular in developing countries. This causes an increasing mismatch between training and research needs, as well as a growing disparity in research capabilities across the world. OpenLabTools aims to develop low-cost scientific tools based on current open source hardware and software projects. The audience the team hope to reach includes students involved in higher education (undergraduate and graduate) and also researchers in academia or research and development labs.

> ***"We are not trying to develop a new cutting-edge technology. We want to use tools already available on the market to design new and flexible products. Our aim is to share results and build a community that will progressively make these instruments better."***
> **Alexandre Kabla, project supervisor**

The objective is not to deliver new technologies or even to match today's state of the art. Their approach is to progressively develop an online repository of tutorials that addresses the key components of today's instruments (sensing, imaging, logging, actuating, etc.) and combine them to build some of the most ubiquitous lab instruments. Designing this knowledge centre and assembling the instruments provide a fantastic training opportunity for undergraduate students.

Undergraduate projects have already heavily contributed to the initiative, in particular thanks to the support of the University of Cambridge's Learning and Teaching Innovation Fund, and the Raspberry Pi Foundation who helped start the project by funding five summer internships in 2013. This year has seen global investments company BNY Mellon, the official sponsor of The BNY Mellon Boat Race, come on board with a £10,000 donation to support the internship project alongside the Raspberry Pi Foundation. The group's first target is the design of an automated microscope, and preliminary blueprints are now available online (www.openlabtools.org), thanks to the work of Chris McNicol, David Purdie, James Ritchie, Thomas Roddick and Marco Selvi.

The image acquisition, analysis and data storage processes of the microscope rely on the low-cost Raspberry Pi computer and its camera module. The supporting frame is built with the OpenBeam technology. The focusing system uses positioning techniques currently used for hobbyist and consumer 3D printers. All non-standard parts have been 3D printed and the designs made available online so that the whole system could be reproduced without workshop facilities. The Raspberry Pi computer also has full control of the microscope stage and illumination thanks to the open-source Arduino microcontroller. A few lines of code then enable the implementation of rather sophisticated features such as auto-focusing or in plane tracking. In the next few months, a team of 4th year students at the Department of Engineering will further explore the imaging capabilities of the microscope, as well as the design of new components for the development of mechanical testing rigs or flow tracking systems. They plan to roll out some of these instruments in undergraduate teaching labs within a couple of years, and use them to train graduate students in instrument design and automation through hands-on workshops.

Strengthening the culture of open-source instrumentation in academia is likely to increase research productivity and innovation by lowering costs and facilitating collaborations on instrument development. OpenLabTools will eventually make it easier for researchers to deploy in their lab existing open technologies by providing detailed instructions primarily aimed at students and academics and a forum for discussion and sharing knowledge.

**www.openlabtools.org/**

# Young Engineering Consultant of the Year: Alumnus Tom Wilcock

**Alumnus Tom Wilcock has been named Young Consultant of the Year by New Civil Engineer and the Association for Consultancy and Engineering.**

Tom, 29, is a senior engineer based in Arup's New York office, and has worked at Arup throughout his career, working on projects including Torre Ejecutiva in Mexico City, Adihe City in Verona, analysis of vibration for a rugby stadium in Dublin, foundation design for Aquamarine Power's Oyster wave energy device, and post-tsunami reconstruction in Sri Lanka. He says it's up to engineers to demonstrate what they do to attract young people into the industry.

Engineering can be a difficult subject to get your head around, even for those within the sector. It covers such a dizzying range of subjects, sectors and job functions, some of which seem to have little or no common ground between them. How much more difficult must it be, therefore, for students and teachers who want to understand what the discipline involves, and how they might find their way into it?

For Tom it was a matter of finding out for himself. Tom is now a member of Arup's Advanced Technology and Research (AT&R) Division, but his association with Arup goes back much further. "When I was 15 or 16, I was trying to decide whether I wanted to do architecture or engineering at university, as I had to decide which A-levels to take and the requirements were different," he said. "At the time, I knew quite a lot about what architects do, but I knew a lot less about the engineering environment and what that involved. So I spent a week doing work experience at Arup, working with one of the engineers in the London office, and that helped me to understand the role that engineers play in helping buildings come to life, but just as important was seeing the passion involved in that process, for what they did and the role they play in society. That triggered my imagination."

Having decided to go down the engineering route, Tom returned to Arup in his post-school gap year on the company's Pre-University Training Scheme, one of a range of schemes run within the sector to place prospective students into real jobs to give them an understanding of what it is to be a professional engineer. 'It was a pre-requisite for the scheme that I was going to study an appropriate engineering degree,' he explained. 'It's a great way to give you the context for engineering. When you later dig into the technical and academic aspects of the profession, understanding the application of the tools you're learning about is incredibly valuable. It makes what can sometimes be an abstract subject in the lecture theatre into something very tangible.'

Tom worked within AT&R during his pre-university year and applied to rejoin it once he'd graduated. Part of the reason, he said, was the spread of projects that the division works on. 'In this group, we apply first-principle problem-solving approaches, which is when you go back to the pure maths and physics of the problems, to deliver simple solutions to complex new problems. It isn't sector-specific. It's one of the things that attracted me to engineering in the first place and it still excites me now.'

Two projects in particular illustrate the breadth of the toolkit Wilcock currently works with; they are both in the built environment, but at diametrically opposed ends of the scale. In one, he led the design of a structure to support the Torre Ejecutiva, a 52-storey tower in Mexico City. The region is highly seismic and the city itself is founded on an ancient lake-bed with very soft soil; when earthquakes occur, this soft base means that buildings can experience very high accelerations. Tom used software that was originally developed to understand nuclear explosions to analyse the forces that could act on the tower; Arup has been bringing this system into the built environment over the past 30 years, he said.

'We ended up designing a very novel lateral resistance system,' he said. 'It's an externally-braced megaframe that sits outside the tower. It has a steel element in it that is like an electric fuse; in an earthquake it attracts damage and dissipates energy through plastic deformation of the steel, so all the damage occurs there and not in the rest of the building. Then it can be replaced.'

> ***"This is a profession that does not have bounds in the application of the skills and methods it teaches. That's a message that we, as engineers, have to deliver."***
>
> **Tom Wilcock, Alumnus**

But Tom has also used this tool to study the performance of buildings made using a traditional technique that has been used for millennia in rural Pakistan, using mud, bricks, timber and stone. 'Sometimes these buildings stand up to earthquakes very well and sometimes they don't,' he explained. 'There isn't any engineering or physics evidence as to why that's the case. The UN is interested in this technique but in order for them to advocate it, it's important that there's a good understanding of how it works and how it can be designed to behave well.'

The project applied Arup's very high-tech analysis tools to this very low-tech technique. 'We've found ways to use the timber connections, metal strapping and the amount of load on the roof to start developing recommendations on how people can build structures as safe as possible, using techniques that they understand and have been already using for many years.'

This type of work illustrates what Tom believes to be the most important contribution that engineers can make. 'There are many challenges in the world at the moment, from climate change to disparities in terms of living conditions and wealth, which are going to require problem-solvers with a very diverse range of backgrounds,' he said. 'When you dig into these problems, you find that access to infrastructure has a very large influence on improving living standards. I feel that it's not always clear to people who are otherwise very aware of these problems that engineers can play an important role in solving them.'

Young people tend to have a good understanding of such issues, Tom said, and showing how engineers can help with them might be an important way to attract them into the profession. 'When you think about engineers, you shouldn't just think about the design of bridges in the UK or design of aerospace systems. There are very real roles that engineers can play in tackling these global problems and that's an exciting message. This is a profession that does not have bounds in the application of the skills and methods it teaches. That's a message that we, as engineers, have to deliver.'

Like many in the profession, Tom thinks that not enough is being done to communicate this message. 'I feel that we, as engineers, bear the responsibility ourselves to go out and demonstrate what we do and the value of what we do. I'm less concerned about things like protection of titles and more about demonstrating that value. There needs to be more engagement with other strands of society to do that, especially with policy makers. We have an opportunity to get our message out there for the benefit of many people. But we haven't yet obtained traction for that message.'

*This article by Stuart Nathan originally appeared in The Engineer Magazine*

**www.theengineer.co.uk**

# 400th Anniversary of Japanese-British Relations

**A custom-made British telescope was presented as a gift to the Japanese nation in place of a rare lost telescope sent by King James I to the Shogunate of Japan exactly 400 years ago.**

The telescope, tripod and presentation case was presented to the people of Japan by Japan400 on 8th September 2013 to commemorate the gift of a telescope from King James to Tokugawa Ieyasu on 8th September 1613, marking the 400th Anniversary of Japan-British Relations in trade, diplomacy, science and culture.

A send-off and mini-conference entitled: 'From King James's Telescope to the Present and Future' was held at Jesus College, Cambridge, in view of the fact that the King's telescope can be considered a scientific instrument, and so marks the beginning of Japanese-British exchange in that field. There were speeches from Lord Rees (Astronomer-Royal), the Department's Professor Roberto Cipolla and case studies by Dr Fumiya Iida (ETH, Zurich), David Cope (Clare Hall) and Professor Paul Alexander (Jesus College).

In June 1613 the East India Company ship, The Clove, had been sent by King James with presents for the ruler of Japan, including the first telescope ever sent outside Europe. The ship commanded by John Saris, arrived at Hirado, as the first British ship to reach Japan. Saris was introduced to Tokugawa Ieyasu and presented with various gifts, the principal one being the large silver gilt telescope.

Telescopes had only just been invented, and this is the first known to have been dispatched from Europe to Asia. That the Japanese were amazed by such technology is demonstrated by many later shoguns asking for European telescopes. Sadly, the original has been lost, and so a hand-made brass British telescope was commissioned as a replacement, to be an enduring symbol of the beginning of Britain's valuable partnership with Japan in science and technology.

The telescope will be offered for display at the British Embassy in Tokyo and a number of locations around Japan with strong British historical connections, before going on permanent display at a final destination in Japan.

**http://japan400.com**

# Inspiring research through industrial collaboration

**The Department of Engineering, supported by the Royal Academy of Engineering, has created a new post of Visiting Professor of Innovation. This post strengthens and extends the work of the Department's strategic theme: "Inspiring Research through Industrial Collaboration".**

The objectives of this post are: to raise the profile of innovation within the Department; to provide inspiration, mentoring and knowledge on the practice of innovation to students and academics; and to strengthen collaboration with industry. This position is shared by three people with different backgrounds and experience: Pieter Knook, Sam Beale and Rick Mitchell. Although they work as a team, each has a particular focus: Pieter Knook on graduate students, Sam Beale on Staff and Rick Mitchell on the undergraduate population.

**Pieter Knook** is currently Chairman of Better Generation (a renewable energy start-up), Pulsant (a UK hosting company focused on Small and Medium Enterprises) and The Institution (a Swedish mobile device management company), and serves on several boards as well as being a Cambridge Angel and Venture Partner with Octopus. He is the former Director of Internet Services at Vodafone, and spent 18 years in senior roles at Microsoft, including Senior Vice President Mobile Communications and President of Microsoft Asia.

**Sam Beale** was, until 2012, Head of Technology Strategy at Rolls-Royce Group. This role included management of the company's University Technology Centre network, and support for the Chief Scientific Officer, the Directors of Engineering and Technology and Research and Technology. He formerly held a range of senior design and engineering positions within the company.

*"We can act as a non-advocate independent group to bounce your ideas off."*
Sam Beale

**Rick Mitchell** is currently a visiting fellow in the Institute for Manufacturing and Visiting Professor of Innovation Management at Cranfield School of management. He is the former Group Technical and Quality Director at Domino Printing Sciences, International Development Manager with Philips Mobile Radio and Senior Corporate Planner for Philips Electronics UK.

**www.eng.cam.ac.uk/research/strategic-themes/inspiring-research-through-industrial-collaboration**

# Near error-free wireless detection made possible

**A new long-range wireless tag detection system, with potential applications in health care, environmental protection and goods tracking, can pinpoint items with near 100 per cent accuracy over a much wider range than current systems.**

ERIK SÖDERSTRÖM VIA FLICKR

The accuracy and range of radio frequency identification (RFID) systems, which are used in everything from passports to luggage tracking, could be vastly improved thanks to a new system developed by researchers at the Department of Engineering.

The vastly increased range and accuracy of the system opens up a wide range of potential monitoring applications, including support for the sick and elderly, real-time environmental monitoring in areas prone to natural disasters, or paying for goods without the need for conventional checkouts.

The new system improves the accuracy of passive (battery-less) RFID tag detection from roughly 50 per cent to near 100 per cent, and increases the reliable detection range from two to three metres to approximately 20 metres.

RFID is a widely-used wireless sensing technology which uses radio waves to identify an object in the form of a serial number. The technology is used for applications such as baggage handling in airports, access badges, inventory control and document tracking.

RFID systems are comprised of a reader and a tag, and unlike conventional bar codes, the reader does not need to be in line of sight with the tag in order to detect it, meaning that tags can be embedded inside an object, and that many tags can be detected at once. Additionally, the tags require no internal energy source or maintenance, as they get their power from the radio waves interrogating them.

"Conventional passive UHF RFID systems typically offer a lower useful read range than this new solution, as well as lower detection reliability," said Dr Sithamparanathan Sabesan of the Department's Centre for Photonic Systems. "Tag detection accuracy usually degrades at a distance of about two to three metres, and interrogating signals can be cancelled due to reflections, leading to dead spots within the radio environment."

Several other methods of improving passive RFID coverage have been developed, but they do not address the issues of dead spots.

However, by using a distributed antenna system (DAS) of the type commonly used to improve wireless communications within a building, Dr Sabesan and Dr Michael Crisp, along with Professors Richard Penty and Ian White, were able to achieve a massive increase in RFID range and accuracy.

> ***"Conventional systems typically offer a lower useful read range than this new solution, as well as lower detection reliability."***
> **Sithamparanathan Sabesan**

By multicasting the RFID signals over a number of transmitting antennas, the researchers were able to dynamically move the dead spots to achieve an effectively error-free system. Using four transmitting and receiving antenna pairs, the team were able to reduce the number of dead spots in the system from nearly 50 per cent to zero per cent over a 20 by 15 metre area.

In addition, the new system requires fewer antennas than current technologies. In most of the RFID systems currently in use, the best way to ensure an accurate reading of the tags is to shorten the distance between the antennas and the tags, meaning that many antennas are required to achieve an acceptable accuracy rate. Even so, it is impossible to achieve completely accurate detection. But by using a DAS RFID system to move the location of dead spots away from the tag, an accurate read becomes possible without the need for additional antennas.

The team is currently working to add location functionality to the RFID DAS system which would allow users to see not only which zone a tagged item was located in, but also approximately where it was within that space.

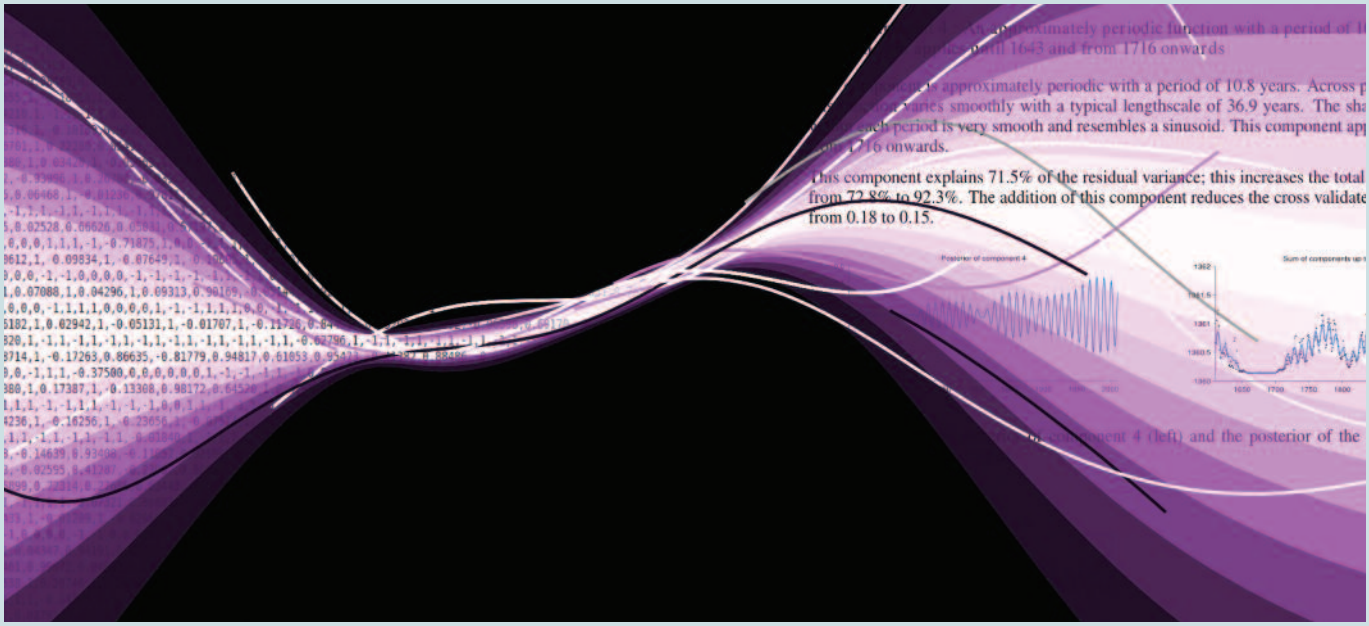
The system, recognised by the award of the 2011 UK RAEng/ERA Innovation Prize, is being commercialised by the Cambridge team. This will allow organisations to inexpensively and effectively monitor RFID tagged items over large areas.

The research was funded by the Engineering and Physical Sciences Research Council (EPSRC) and Boeing.

**www.epsrc.ac.uk**

# Super-fast and super-green: Cambridge unveils pioneering high-performance computer

**A super energy-efficient high-performance computer, with a performance equivalent to 4,000 desktop machines running at once, will enable researchers to handle the Big Data challenges of the future – not least the design of a system to support the world's largest telescope.**




ZOUBIN GHAHRAMANI

One of the world's greenest supercomputers has been unveiled by the High Performance Computing Service at the University of Cambridge.

Named "Wilkes", after the Cambridge pioneer Maurice Wilkes who built one of the first ever programmable computers in 1949, the new system has been rated second in the "Green 500" – a ranking of the most efficient supercomputers worldwide. It is, however, the most efficient air-cooled supercomputer in the world today (the first-placed machine used an oil-cooled system instead), making it the greenest machine of its kind.

Designed and built by the in-house engineering team within the Cambridge High Performance Computing Service, Wilkes' energy efficiency is 3,361 Mega-flops per watt. "Flops" (floating point operations per second) are a standard measure of computing performance.

Dr Paul Calleja, Director of the Cambridge High Performance Computing Service, said: "Energy efficiency is the biggest single challenge in supercomputing today and our new system makes an important step forward in this regard."

The Dell system uses innovative NVIDIA graphics processing units (GPU) computational hardware, and apart from its green credentials is also the fastest GPU supercomputer in the UK – with a sustained performance of 250 "Teraflops". It reached position 166 in the Top 500 list of the world's fastest supercomputers. This is equivalent to approximately 4,000 desktop machines all running as a single system.

One of the primary uses of Wilkes is as a test bed for the development of a computing platform for the Square Kilometre Array (SKA). This is a huge, international effort to build the world's largest telescope. By detecting radio waves with unprecedented sensitivity and fidelity, the facility has the potential to answer some essential questions about the Universe, such as what the nature of dark energy is, and perhaps the most fundamental question of all – are we alone?

Cambridge is leading the design of the computational platform within the SKA, which is by far the world's most ambitious IT project. "Wilkes" will play an integral role in this design process.

> ***"The total facility is one of the most energy-efficiency data centres in the world. "***
> **Paul Calleja**

The architecture of the GPU system has also been designed to be the most scalable possible using the very latest high-performance Infiniband network from Mellanox. This provides a massive 100 gigabytes per-second bandwidth, and a message rate of over 137 million messages a second.

This scalability will be used to drive the discovery process across a broad range of research activities within the University. For example, the system will be used to design and test jet engines, design new drugs to fight cancer, and examine the fundamental nature of the nucleus of the atom.

One particular research group, headed up by Dr Graham Pullan of the Department of Engineering, has already developed GPU-optimised computational fluid dynamics software called "Turbostream" to model the air flow within jet engines which, when combined with the new GPU system, offers ground breaking capability in turbine research.

The GPU system is housed in a custom-developed "green data centre", which uses evaporative air-coolers and water heat-exchangers to boost its environmental credentials further. "Together, the cooling and processing systems behind Wilkes dramatically reduce the power consumption in the data centre, making the total facility one of the most energy-efficiency data centres in the world," Paul said. "Also, the new SKA development lab places the University at the forefront of large-scale, big-data platform development."

Maurice Wilkes was the man behind EDSAC, the first programmable computer to come into general use. Built in 1946, it put Cambridge at the forefront of the digital revolution. More than six decades later, this latest supercomputer, bearing Wilkes' name, is destined to write the next chapter in that ongoing story.

The computer was designed in partnership with Dell, NVIDIA and Mellanox, and was part-funded by the Science and Technology Facilities Council, Rolls-Royce, and Mitsubishi Heavy Industries.

**www.hpc.cam.ac.uk**

# ICE Awards for Professor Robert Mair and Professor Gopal Madabhushi

**Two prestigious awards were presented to Professor Robert Mair and Professor Gopal Madabhushi at the recent Awards Ceremony at the Institution of Civil Engineers (ICE) in London. The President's Medal was presented to Professor Mair and the T K Hsieh Award to Professor Madabhushi and his co-authors.**

Professor Robert Mair

Professor Gopal Madabushi

The citation for Professor Mair stated: "The ICE President's Medal for 2013 is awarded in recognition of innovation that is delivering a step change in design and construction... Professor Mair is internationally recognised for his work on underground construction involving soft ground tunnelling, retaining structures, deep excavations and foundations. He leads the Centre for Smart Infrastructure and Construction which focuses on the innovative use of emerging technologies in sensor and data management...it is already impacting on major construction projects achieving transformational change in performance, efficiency and cost".

The T K Shieh Award is given annually to the authors of the best paper published by the Institution of Civil Engineers in the field of structural and soil vibration caused by mechanical plant, waves or seismic effects. Professor Madabhushi's paper 'On the behaviour of flexible retaining walls under seismic actions' was recently published in Géotechnique. His co-authors were Professor Giulia Viggiani and Dr Riccardo Conti of the University of Rome Tor Vegata, both of whom have been recent visitors to the Department.

**www.ice.org.uk**

# Department receives Athena SWAN equality award

**The Department of Engineering was praised for its mentoring scheme for newly-appointed staff at an Athena SWAN awards ceremony.**


ATHENA SWAN

Presentation of Athena SWAN awards with Professor Keith Glover and Dr Kate Knill on the far left

Professor Keith Glover and Dr Kate Knill from the Department attended the awards ceremony at Imperial College, London, to receive the Bronze Award from Athena SWAN patron Professor Dame Julia Higgins FRS FREng.

Academic institutions from all over Great Britain were honoured at the event which was addressed by Professor Dorothy Griffiths, Professor Dame Julia Higgins, David Ruebain, Chief Executive, Equality Challenge Unit, Professor James Stirling and Professor Tom Welton.

***"I have for a long time been concerned about the gender imbalance in Engineering and so I am delighted that the Department has received this award in recognition of our commitment to equality."***
**Professor Dame Ann Dowling**

In applying for the Bronze Award, the Department had to submit a variety of data, analysed by gender, including such information as academic staff recruitment, promotion and turnover, the demographics of committees and decision-making panels, paternity, adoption and parental leave uptake, alongside more traditional analysis of academic staff and student numbers. In addition to identifying particular challenges, the submission also had to lay out plans for the future and how these issues would be addressed.

Professor Dame Ann Dowling, Head of the Department, said: "I have for a long time been concerned about the gender imbalance in Engineering and so I am delighted that the Department has received this award in recognition of our commitment to equality. I believe this is crucial for a supportive, congenial and successful department. We have already started to implement our Athena SWAN action plan and are benefitting from it. Thirty per cent of our recently appointed academic staff are women and our Women in Engineering Forum provides a clear focus for activities, support and information for women across the Department from undergraduates to senior Academic staff."

Current initiatives within the Department include the launch of a highly successful Women in Engineering Forum and Women in Engineering website, www-womeninengineering.eng.cam.ac.uk.

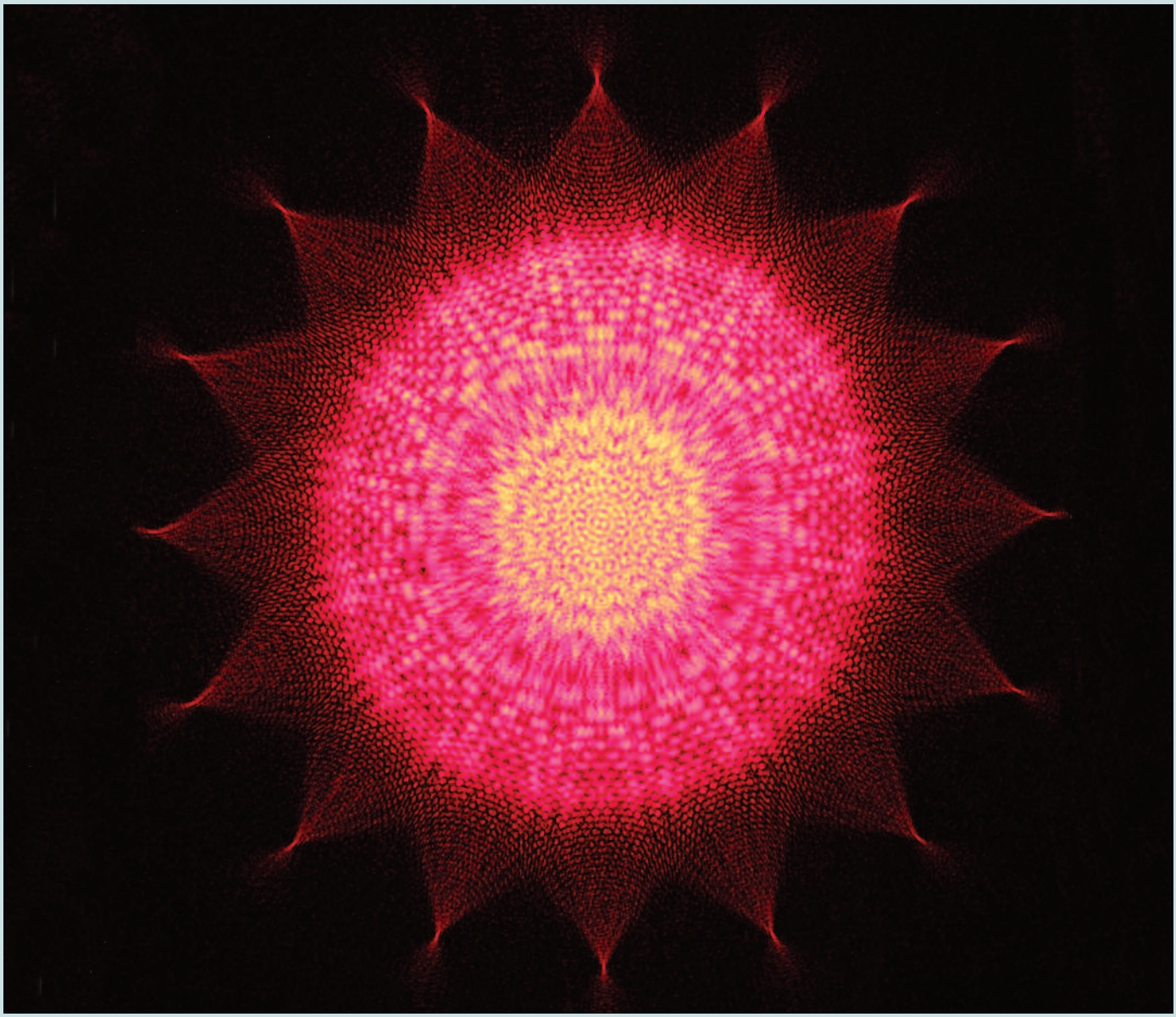
The Athena SWAN awards process highlights the innovative work going on in institutions to advance the Athena SWAN principles. For each round an Awards booklet is published which sets out some of the good practice highlighted in the awards submissions. The 2013 booklet praised the Department's "good practice" of assigning a mentor from outside the management chain to each newly appointed member of academic staff.

Running since 2005, the Athena SWAN Charter awards recognise the commitment of the higher education sector to address gender inequalities, tackle the unequal representation of women in science and to improve career progression for female academics. The University of Cambridge is a founder member of the Charter and has a Bronze Award.

**www.athenaswan.org.uk**

# Inspiring images: Engineering captured on camera

**From rainbow coloured liquid-crystal molecules, to tunnels deep under the ground, this year's entries from the Department of Engineering photo competition help to bring engineering brightly and vividly to life.**



The competition aims to show that engineering is not only about fixing machines and building bridges, but involves everything from studying objects and processes in microscopic detail, to building towering structures. The winning images can be viewed on the Department's Flickr website, www.flickr.com/photos/cambridgeuniversity-engineering/sets/, where they can be accessed alongside dozens of other entries.

The competition, sponsored by Zeiss, international leaders in the fields of optics and optoelectronics, had five categories this year; alongside those for first, second and third place, prizes were awarded for a micrograph captured using an electron microscope, the Zeiss SEM prize, and a Head of Department's prize for the photo or video with the most innovative engineering story behind it.

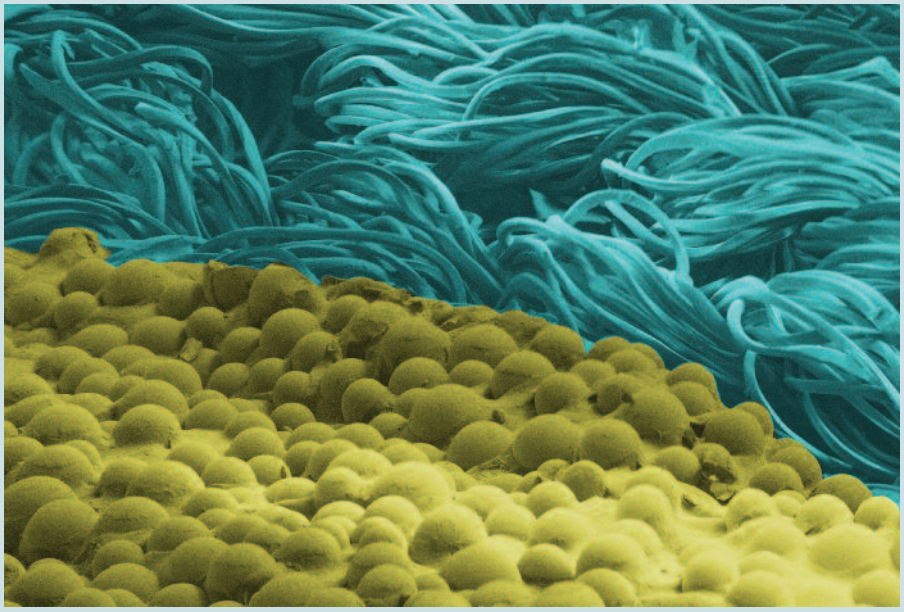
The images entered must be related to research or teaching undertaken in the Department, or out in the field; anyone working in the Department is eligible to enter, whether a professor, student, or member of support staff. Entrants were told that the images they entered may be "beautiful, fascinating, intriguing, amusing, or possibly all of these things".

The panel of judges included Dr Allan McRobie, Professor Dame Ann Dowling and Philip Guildford, all members of the Department of Engineering. Ken Robinson, Senior Applications Specialist at Zeiss, also judged the entries. Philip Guildford, Director of Research , said that entries for this year's competition had once again impressed the judging panel.

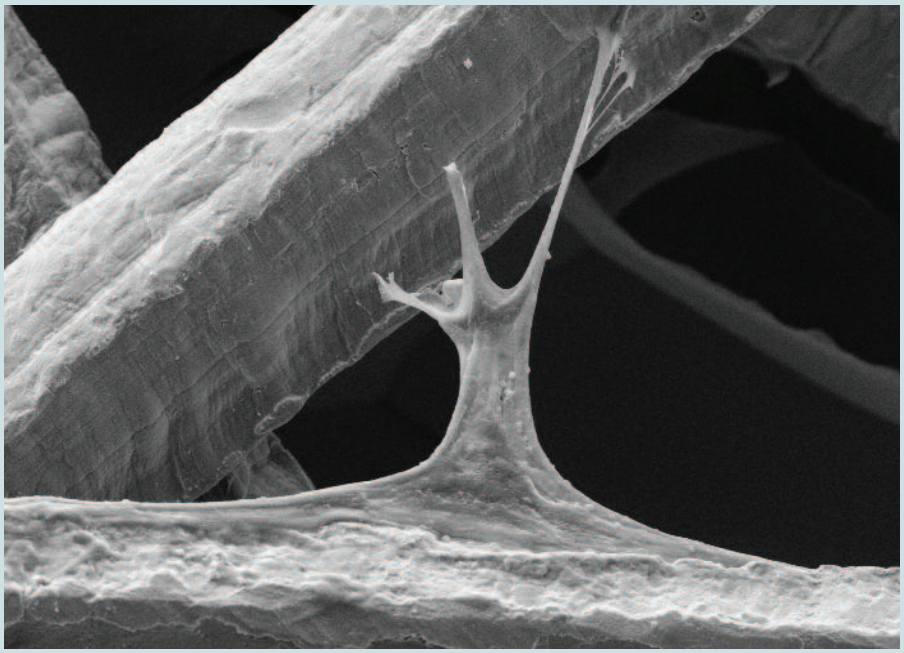
"The winning images are diverse, beautiful and meaningful," Guildford said. "They all tell wonderful stories of engineering students,

▲ The **first place prize** was awarded to **Ananta Palani's** entry entitled "Diffraction Sun". The PhD student shone a laser light onto a small liquid crystal device, causing the light to interfere with itself and become diffracted. Palani's sun-like image is the result of this diffraction. The research behind this image could potentially help create a microscope that would allow people to see very fast and very small objects, such as a virus infecting a cell, which at the moment can only be observed with great difficulty.

This year we would like to extend our successful student and staff photography competition to all alumni of the Department of Engineering. Your chance to win a bottle of wine (the vintage of which will be the year you matriculated) or a year's supply of Chelsea buns from Fitzbillies (UK addresses only). Rules and further information from www.eng.cam.ac.uk/news/alumni-photography-competition-department-engineering



**Ioannis Mastoris** and **Ronan Daly** were the joint winners of the **second prize** with their electron microscopy image of the reflective coating and fibrous cloth of a man-made fabric. This photograph was taken as part of a research project focusing on the lifecycle of these fabrics, from which the findings could be utilised to help decrease the environmental impact of the fibre-dyeing process.



researchers and academics seeking to discover new scientific truths and advance technology. The winners give an eye-catching glimpse of work in the Department of Engineering, but there were over 150 other entrants this year, each communicating their unique message of how engineering is advancing and helping the World. The breadth and quality of work is quite staggering."

Finally, the **Head of Department prize** was awarded to **Khaow Tonsomboon** for his video showing, step-by-step, how fibre-reinforced hydrogels can be created to mimic the structure and composition of a cornea, the transparent front part of the eye. These hydrogels have potential real-world applications, especially as the manufacturing process is cost-effective, simple, and involves non-toxic components.

You can view the video on the Department's YouTube channel: www.youtube.com/EngineeringCambridge

There were many other outstanding images entered into this competition, including Kai Ying's Chemical Vapour Deposition (CVD) graphene samples that look like a starry sky at night, Eric Pickering's sequential frames charting a ballistic impact, and Tom Rainforth's flower shaped simulation of a chaotic attractor.

**Phil Catton**, who works in the Department's Centre for Smart Infrastructure and Construction (CSIC), won **third prize** for his image entitled "Mirror Finish". In this photograph researchers are using a 3D laser scanner to measure deformations in the London Underground Northern Line station at Euston. The information collected will then be fed into CSIC-developed models for analysis, in order to predict the behaviour of future complex tunnel geometries; these predictions will be a valuable tool in the future as new underground tunnels are built.

The **Zeiss SEM prize** was awarded to **Brajith Srigengan** for his image of an osteoblast (bone cell) branching across two steel fibres. It was photographed as part of a research project focusing on the effect that coating a hip implant with fibrin, a protein gel, has on the body's inflammation process. A 3D steel fibre network was used as an in-vitro model of the implant. The images were then used to provide a qualitative analysis of the response.

***"The winning images tell wonderful stories of engineering students, researchers and academics seeking to discover new scientific truths and advance technology."***
**Philip Guildford**

**All entries can be viewed at: www.flickr.com/photos/cambridgeuniversity-engineering**

# Machine Learning paper wins Classic prize

**The authors of a machine learning research paper have been awarded a prize for their work – ten years after the initial paper had been rejected.**

The 2013 Classic Paper Prize at the International Conference on Machine Learning (ICML) was won by Zoubin Ghahramani and co-authors Xiaojin Zhu and John Lafferty for their 2003 paper "Semi-Supervised Learning Using Gaussian Fields and Harmonic Functions". The Classic Paper Prize is given to the paper published at ICML 10 years previously which has had the most impact on the field.

Zoubin Ghahramani, Professor of Information Engineering in the Department of Engineering, said: "I'm delighted that our paper won this award. Interestingly, this paper was a revised version of a paper that had been rejected from another major conference, the Neural Information Processing Systems Conference (NIPS).

"Perhaps a moral to this story for young researchers is not to take rejection to heart. I am chairing NIPS this year, so when I send out about 1000 rejections in a couple of months I will be wondering how many of those rejected papers contain ideas which in 10 years will have, or could have had, a major impact on the field!"

This 2003 paper, which has now been cited over 1400 times, developed a simple and highly-scalable graph-based method for semi-supervised classification, and related it to harmonic functions, random walks, electric networks, and spectral graph theory. Graph-based semi-supervised learning has now become a standard approach for combining labelled and unlabelled data in many application domains. Semi-supervised learning refers to the problem of combining small amounts of labelled data (i.e. supervised learning) with large amounts of unlabelled data (i.e. unsupervised learning).

Zoubin added: "The web has made available vast amounts of unlabelled text, images, videos, music and other kinds of data, and many fields of science now collect and share vast amounts of scientific data, but obtaining high-quality labels or annotations is still difficult. This is exactly the scenario where semi-supervised learning is particularly valuable: when obtaining labelled data is expensive or time-consuming, but unlabelled data is cheap and plentiful."

**http://mlg.eng.cam.ac.uk**

# Royal Academy of Engineering nominates its first female President

**The Council of the Royal Academy of Engineering has nominated Professor Dame Ann Dowling FREng FRS, Head of the Department of Engineering at the University of Cambridge, as its Presidential candidate for election by Fellows at the September 2014 AGM. Upon election by the Fellowship, Professor Dowling would become the Academy's first female President and serve a term of five years.**

A world authority on combustion and acoustics, Professor Dowling became a Cambridge research fellow in 1977 and has remained at the university ever since, including visiting research posts at MIT in 1999 and Caltech in 2001. In 1993, she became the Department of Engineering's first ever female professor. In 2002, she was recognised in the Queen's Birthday Honours, receiving a CBE for services to Mechanical Engineering, and again in the 2007 in the New Year's Honours List when she received a DBE for services to science. In 2011, she was awarded a UK Resource Centre award for her 'Inspiration and Leadership in Academia and Research'.

She said: "I am honoured to be nominated for election as President of the UK's national academy of engineering at a crucial time when it is generally acknowledged that many more engineers will be required to help the country benefit from the knowledge economy of the future. The world faces some enormous challenges, including clean energy, resilient infrastructure, water and food supply, and engineers have a crucial role in addressing these issues."

Professor Dowling started her career as a mathematician but always wanted to pursue applied mathematics and did her PhD in engineering acoustics with Professor John Ffowcs Williams FREng, who led pioneering noise-reduction research on Concorde. She now leads research on efficient, low emission combustion for aero and industrial gas turbines and low noise vehicles, particularly aircraft and cars.

Her work in aeronautics and energy has been recognised by fellowships of the Royal Society and Royal Academy of Engineering, and foreign associate membership of both the US National Academy of Engineering and the French Academy of Sciences. Professor Dowling led the Cambridge MIT Silent Aircraft project, which published its radical new design concept SAX-40 in 2006 with the aim of raising aircraft industry aspirations.

***"I am honoured to be nominated for election as President of the UK's national academy of engineering at a time when it is generally acknowledged that many more engineers will be required to help the country benefit from the knowledge economy of the future."***
**Professor Dame Ann Dowling**

She also chaired the agenda-setting and widely-respected joint Royal Society/Royal Academy of Engineering report Nanoscience and nanotechnologies: opportunities and uncertainties, published in 2004, which highlighted the need for responsible regulation and research around the use of materials at an extremely small scale - only a few millionths of a millimetre.

Professor Dowling is a non-executive director of BP, a panel chair for the Research Excellence Framework and was nominated in BBC Radio 4 Woman's Hour power list 2013 as one of the 100 most influential women in the country.

Academy President Sir John Parker GBE FREng said: "I am delighted that Professor Dowling has been nominated for election as the next President of this Academy. Her wide research and policy expertise and her leadership of the engineering department of one of the world's top universities will be a great asset to the Academy in the years to come."

**www.raeng.org.uk**

# Holding the future of smart sensors in the palm of her hand

**A new, unique and tiny sensor device named Utterberry, designed and developed at the Department of Engineering and deployed in the Centre for Smart Infrastructure and Construction's projects, could potentially transform infrastructure monitoring and possibly even act as a remote sensor for human health monitoring in the future.**

"The Utterberry has the potential to become ubiquitous in the world of sensing," says Professor Kenichi Soga, Professor of Civil Engineering. "It's cute, clever and incredibly capable and has huge potential in sectors such as healthcare and building's monitoring."

The Utterberry is the work of PhD student Heba Bevan. She has been working with Professor Soga to design and develop the wireless, low power sensor, which is capable of monitoring large scale assets such as tunnels and bridges.

"The Utterberry has a number of attributes", says Heba "but the one which makes it stand out is its size. It's about the size and weight of two £1 coins put together which means it compares favourably to current sensors which are around the size of a box of teabags and about as heavy as a bag of sugar."

Heba Bevan


The Utterberry

Sensors are used to monitor the health and safety of large infrastructure assets – such as buildings, bridges and tunnels. The small size of the Utterberry means it has practical and economic benefits when it comes to being deployed: "The fact it is so small and light means it is easy to carry as well as install and needs only one person to do this rather than a team of people" explains Heba.

Although small enough to fit in the palm of your hand, the Utterberry is also robust enough to withstand the elements of hazardous environments, home to many sensor devices: "I have tested the Utterberry in tunnels deep underground in London and also high on the Forth Bridge in Scotland. It is small but strong."

The fact that the Utterberry was shortlisted and certified as 'Highly Commended' in three Institution for Engineering and Technology (IET) Innovation Awards - the Asset Management Award, the Built Environment Award and the Measurement In Action Award – is testament to its applicability.

"It has many other benefits," continues Heba, "it uses almost no power – in fact it is approaching a zero power requirement – that's as much as the fundamental laws of physics will allow!

"It's actually like a miniature computer with its own network control software, making it clever and reliable."

Powered by a microprocessor, the Utterberry is able to determine whether the wireless conditions are favourable or not and it is able to adapt its communication behaviour accordingly.

Before undertaking her PhD Heba worked for ARM – one of the world's technology leaders in mircoprocessors. "I was fortunate enough to be one of their central-processing-unit (CPU) designers and so what makes the Utterberry extra special to me is that I was one of the people who was involved in the design of the processor chip that's inside my device as well!" says Heba.

***"The Utterberry has a number of attributes but the one which makes it stand out is its size. It's about the size and weight of two £1 coins put together which means it compares favorably to current sensors which are around the size of a box of teabags and about as heavy as a bag of sugar."***
**Heba Bevan, PhD student**

Being wireless allows feedback data from the monitored asset to be accessed remotely by civil engineers rather than them having to be on site. "This makes both practical and economic sense," explains Heba "as it avoids having to close down railway stations, for example, to install the sensors, as well as having to crawl around in tunnels beneath London or climb 200 feet above the Forth Suspension Bridge north of Edinburgh to get access to the data and monitor the condition of the asset in question."

The potential of the Utterberry could take it beyond the realms of infrastructure application. One area Heba is keen to see it work in is the healthcare system. "I come from a family of medics and I wanted to design something that might also eventually help the medical profession and benefit society. These devices are so small and light, they could be easily clipped onto a piece of clothing, making it possible for a doctor to remotely monitor the health of a patient from home after a medical procedure."

Heba is proud to have had her device recognised in this way by IET: "I'm both delighted and excited that the Utterberry has been shortlisted as it demonstrates my technology means something - not just to me but to Industry at large. It is also important to me as there aren't many women in the engineering world and I want to show young people out there and young women in particular that it is possible to be creative and clever – to think about neat solutions to problems and be able to achieve them – and I like to think the Utterberry brings a more feminine solution in what is still largely a man's world."

**www-smartinfrastructure.eng.cam.ac.uk**

# PhD student Tim Newman wins Best Presentation award: Towards a silent fan project

**Dyson sponsored PhD student Tim Newman, has won First Prize in the Best Student Paper Award competition at ICA 2013 Montreal for his paper titled 'A six sensor method for measuring acoustic properties in ducts'.**

Mr Timothy Newman, Professor Dame Ann Dowling, Mr Frederic Nicolas, Sir James Dyson, Dr Anurag Agarwal with early version of the rig

With 2300 registrants, over 1600 technical papers, and 49 exposition booths, ICA 2013 was one of the biggest programme meetings in acoustics ever. The technical program included papers covering all branches of acoustics. Dyson-sponsored PhD student Tim Newman was awarded First Prize in the Best Paper Awards for students in his category. His paper was also published in Proceedings of Meetings on Acoustics (POMA) an online, open-access, proceedings journal from the Acoustical Society of America.

The aim of the project is to investigate air movement for high efficiency and low noise in the power range of small-scale (e.g. domestic) applications. It is part of a new and expanding collaboration between the Department of Engineering and Dyson Ltd, the UK manufacturing company. The Dyson Air Multiplier™ desk fan is used as the test case for a fan optimised for low noise. The product works by drawing air in through the base of the product and expelling it through a narrow ring-shaped gap in the hoop-like 'amplifier'. This annular jet of air entrains large amounts of surrounding air to flow through and around the hoop.

By looking at the components of the product in isolation, it is clear that the main noise source is the compressor in the base which drives the flow of air. Much of the noise is generated aerodynamically and contains broadband (like the sound you hear when you put your head out of a moving car window) and tonal components (as a result of the spinning compressor blades). Tim and his team want to understand exactly how the noise is generated and find ways to reduce the noise at the source. In order to do this, they have designed and constructed an experimental rig. This consists of the compressor at the centre of a pipe with a variety of instruments downstream and upstream of the compressor to measure its performance (e.g. efficiency). A key focus of the paper was the novel method developed to measure the sound emitted into the pipe. By combining the sound measurements from an array of microphones mounted internally on each side of the compressor, they were able to study the structure of the soundfield generated by the fan and isolate the sound sources from other effects such as reflections at each end of the pipe.

This differs from the internationally-standardised (ISO) method which relies on large so-called 'anechoic terminations' which absorb sound at each end to prevent reflections or echoes. The resulting ISO rig, as used at Dyson, is around 14 meters long whereas the experimental rig is around 2 meters long and fits comfortably inside the anechoic chamber in the lab.

***"We are interested in finding novel ways to move air quietly."***
**Tim Newman, PhD student**

An important feature of the experimental rig is that it is modular and adaptable. Furthermore, the sound measurement methodology can be applied to many air-moving sound sources in a pipe or duct. This makes it possible to use the research for other applications such as HVAC systems (Heating, Ventilation and Air Conditioning) common in buildings and vehicles. The collaborators on this paper were: From the Department of Engineering – Mr Timothy Newman, Dr Anurag Agarwal and Professor Dame Ann Dowling. From the Aero-Acoustic Research Team at Dyson – Dr Ludovic Desvard and Mr Ryan Stimpson.

**http://acoustics.eng.cam.ac.uk/people/research-themes/towards-a-silent-fan**

# Dr Mauro Overend recognised for 'outstanding achievement' in structural engineering

**Dr Mauro Overend has become the first UK-based engineer to be awarded the International Association for Bridge and Structural Engineers (IABSE) prize.**

DR MAURO OVEREND

Tate Modern extension, London (currently under construction)

BBC Broadcasting House

The IABSE Prize honours a Member early in his or her career for outstanding achievement in the field of structural engineering, in research, design or construction. A senior lecturer in Building Engineering Design at the Department of Engineering, Mauro was awarded the 2013 prize for "pushing the boundaries in the structural use of glass in façade design, and for related research".

Mauro has a leading international reputation in the field of structural glass. After working as a structural and façade engineer on a number of notable buildings, he returned to full-time teaching and research. He now co-ordinates the Glass and Façade Technology Research Group (www.gft.eu.com), undertaking fundamental, application-driven and interdisciplinary research using his knowledge as a designer of cutting-edge façades and other glass structures.

On receiving his prize, he said: "I am absolutely delighted to be awarded the IABSE Prize. It is an honour and rather humbling to join a list of previous winners who have made significant contributions to structural engineering and to society as a whole.

"The prize is partly recognition of my achievements to-date and partly an encouragement to continue to pursue this very exciting area of research. This would not have been possible without the support of numerous outstanding colleagues and students who have contributed to my work and who will no doubt continue to play a major role in my future work."

Mauro's work is rooted in structural engineering but is interdisciplinary in nature and is at the interface of engineering design and research. During his former roles in consulting engineering, he established the Research & Development Task Group at Ramboll UK (formerly Whitbybird) and worked on projects that involved prototype testing and development to push the boundaries of glass and façade engineering. The Yauatcha store in London with its extensive use of adhesive bonding of glass elements, and the glass structure and connections specially developed for the Breathing Sculpture located on top of BBC Broadcasting House are two such examples.

Similarly, in his current role at the Department of Engineering he collaborates closely with industrial partners to steer the fundamental research of his group towards solving real-world problems in glass and façade engineering. This approach is evident in his research collaborations that range from the development of adhesive and soldered connections for glass elements, through to work on composite glass structures, leading to structurally efficient, safer and thermally efficient facades.

Mauro's research on structural glass, particularly on glass strength models, fragmentation and connections, has a significant impact in this field. The impact of his research, however, extends beyond the built environment as seen in his recent collaborations on monolithic fire resistant glass for marine applications with Trend Marine Ltd, and his on-going work on window pane testing for the manned spacecraft with Magna Parva and the European Space Agency.

Since returning to full-time teaching and research, Mauro has also contributed to the development of challenging real-world projects, most notably the numerical form-finding work for the Grand Theatre in Rabat, Morocco, designed by Zaha Hadid Architects and the experimental and analytical work on the stability of perforated brickwork façade on Tate Modern, London, designed by Herzog & de Meuron Architects.

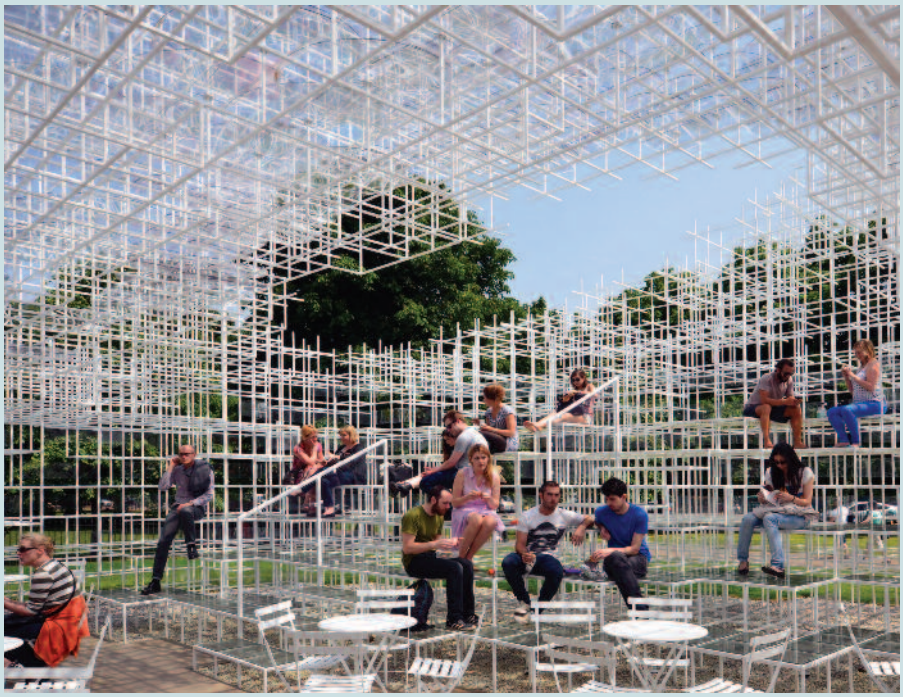
***"The prize is partly recognition of my achievements to-date and partly an encouragement to continue to pursue this very exciting area of research."***
**Mauro Overend**

**www.iabse.org/**

# Alumna Harriet Eldred wins Young Structural Engineer of the Year Award 2013

**Harriet Eldred has been awarded the prestigious Young Structural Engineer of the Year Award 2013 by the Institution of Structural Engineers for her work on this year's Serpentine Pavilion.**

GEORGE REX



The Serpentine Pavilion

Harriet is a structural engineer, working within AECOM with a focus on advanced analytical design, complex geometry generation and parametric design. She has worked with the AECOM design team to develop the Serpentine Pavilion's matrix-like structure and has worked on an array of challenging projects including stadium designs for the 2016 Rio Olympics. Harriet has devised a complex parametric toolkit. Developed for Rio and adapted for the Serpentine, these new processes have made the exchange of information between the design team simpler and quicker, helping to deliver the architect's astonishing vision in a matter of weeks.

As the lead structural engineer for the Serpentine Pavilion 2013, Harriet has been heavily involved in both developing the structural concept as envisioned by Japanese architect, Sou Fujimoto through to completion. Harriet's role was to mask the complexity of the structure behind simple design and intelligent detailing, delivering cutting-edge engineering. The use of her parametric toolkits to analyse and refine a very complex model have been instrumental in allowing AECOM to overcome the structural engineering challenges of this project to deliver a successful recreation of the architect's vision in a four month programme.

Having joined AECOM in 2009 as a graduate from the Department of Engineering, Harriet successfully delivered a £35m new build school and £100m council office, demonstrating her sound engineering skills and deep understanding of client needs. Harriet has also been instrumental in establishing AECOM's structural fire engineering team in the UK. She carried out her own research into the subject and, through working closely with AECOM's fire engineers, has successfully delivered a number projects, ensuring AECOM is at the leading edge of this field of work. Upon receiving news of the award, Harriet said: "I'm honoured to be awarded Young Structural Engineer of the Year. This project has been one of the biggest challenges of my career to date, both in terms of complexity and timescale but the bigger the challenge, the bigger the reward. This is one of the most exciting projects AECOM has given me the chance to work on."

***"It's a great honour to be recognised by such a prestigious Institution and it's something that I will be proud of for the rest of my life."***
**Harriet Eldred**

"Harriet has outstanding technical abilities and combines this with an innovative flair for design and research," said David Glover the AECOM global lead for Building Engineering. "Harriet has achieved much in the first four years of her career, but I suspect the best is yet to come." The Institution of Structural Engineers is the world's largest membership organisation dedicated to the art and science of structural engineering. The Award is given to young structural engineers who demonstrate outstanding performance and show exceptional promise for the future.

Each year, the Serpentine Gallery in London commissions an international architect to design their summer pavilion. The 2013 Pavilion was designed by the Japanese architect Sou Fujimoto, and AECOM were appointed to carry out the structural design from concept stage to completion. Designed as a flexible, multi-purpose social space, with a café inside, visitors were encouraged to enter and interact with the Pavilion throughout its four-month tenure in London's Kensington Gardens.

As part of their entries, candidates were required to submit a 2000 word report on a project in which they had significant input, which also demonstrated creativity and originality.

Anne Fuller, Director of Building Engineering at AECOM, was one of the Award judges. She said: "It is a privilege to judge the Young Structural Engineer of the Year Award. The amazing work being undertaken by some of our young engineers is truly impressive and demonstrates the talent that we have coming into our profession."

The Serpentine Gallery's annual Pavilion is an opportunity for an international architect to showcase their expertise in the UK. Each pavilion is intended to be an example of contemporary architecture and cutting-edge engineering which aims to inspire and intrigue everyone who has the opportunity to visit the venue during its short lifespan. The design and fabrication of the 2013 Pavilion had to be completed within four months, adding additional pressure to the design and fabrication teams. Collaboration and exchange of electronic design information was vital to the success of the project.

The concept is built around a three dimensional 400mm grid, with 20 mm square hollow sections forming a Vierendeel space frame which provides areas of shelter, formed by the addition of circular polycarbonate discs, as well as areas where guests are invited to climb over the structure.

The complex nature of the structure meant that a three dimensional analysis model was essential as the structure relies on all 23,000 members for global stability. In the areas where guests are permitted access onto the structure, locally high loading was

imposed to allow for the weight of the glass infill panels and the weight of a crowd gathered on the structure. This was combined with accidental load combinations which accounted for unwanted access onto the roof, member removal and settlement of the footings.

From the outset it was clear that the detailing of the nodes was vital; they needed to be simple to fabricate, allow easy construction of larger modules for delivery to site as well as on site connections, and they needed to be able to transfer the full moment capacity of the section across the joint.

Several concepts were drawn up and design sessions with the fabricator allowed a detail to be developed which enabled the structure to be constructed in the available timescales. Separate details were needed for the site connections.

It was necessary to ensure that the joint could mobilise the full moment capacity of the steel section as this was fundamental to the stability of the structure, which relied on vierendeel action of the frames and the corresponding high moments at node points. To ensure that the capacity of the joints was sufficient, several test pieces were created and tested to destruction. This included small scale single nodes as well as large scale mock-ups of portions of the structure.

The success of the scheme relied upon electronic collaboration between the design team members. From the outset of the project the design concept was conveyed using 3D models, as the complex structure has very little meaning when expressed as two dimensional sections. The architectural scheme was drawn up using Rhino and bespoke scripts were used to transfer the geometry to Scia Engineer. Fundamental to the success was the ability to make this a complete round trip process, allowing rapid design development with the architect and iteration of the design to a final solution which embodied the architect's dream as well as functioning structurally.

Harriet Eldred

# Cambridge in Africa Programme to facilitate trial road construction in the Niger Delta

**The trial construction of a road in the Niger Delta region of Nigeria has been made possible through generous funding from the Cambridge-Africa Alborada Research Fund through the Cambridge in Africa Programme.**

Funmi Alayaki

This is part of a collaboration between Dr Abir Al-Tabbaa and PhD student Funmilayo Alayaki, from the Department's Geotechnical and Environmental Group, and Professor Josiah Ayotamuno, Dean of Engineering at Rivers State University of Science and Technology (RSUST). The Niger Delta Development Commission (NDDC) have also offered significant in-kind contributions.

The Niger Delta region is plagued with failed and deteriorating roads which have greatly impaired economic growth in that region with adverse effects on the social and environmental dimensions. The area is swampy and the soils are problematic: expansive, highly acidic and gap- or poorly-graded. There is significant lack of understanding of the local soils and their engineering properties and so these soils are usually used as road sub-bases without any treatment or stabilisation. This in turn leads to such persistent road failures. Funmi's PhD work is investigating the improvement of the performance of these problematic soils through their stabilisation with a range of cementitious binders. In a trip to the region last summer, Funmi collected site soils, which have been characterised in the laboratory and are currently being tested following stabilisation. The use of binders, which are locally available, including fly ash from a local thermal desorption facility, will be maximised to minimise costs.

The Cambridge-Africa Alborada Research fund was established with generous support from The Alborada Trust, to help researchers from Sub-Sahara African institutions and the University of Cambridge to initiate and/or strengthen collaborations (across all disciplines), by providing funding for research and travel costs.

Funmi returned to Nigeria to obtain soil samples from the exact location of the proposed trial road and to conduct large scale laboratory treatability studies using those soils in the laboratories at RSUST. The trial road construction started in November 2013, at the start of the dry season in that area. Coring will be carried out following construction and then again following months of traffic use and environmental exposure. PhD students from RSUST will also be involved in this initiative as part of their studies which will strengthen collaboration between the two groups. An outline of a large collaborative proposal was submitted to the NDDC on the development of a sustainable road construction and maintenance system in the Niger Delta. This will involve much larger field trials of road construction and will include on-site monitoring and assessment over a number of years and will also address the broader range of problems there including environmental pollution issues, material selection, construction practices and quality control as well as the reliability of the codes of practice. It is hoped that the trial road construction as part of Funmi's PhD work will pave the way for this much larger project and longer-term collaboration prospects.

**www.geo.eng.cam.ac.uk**

# Online aid for sustainable businesses

**A new online toolkit for manufacturers and retailers has been released to enable users to pinpoint areas in which their businesses could be more environmentally sustainable and profitable.**


WISCONSIN DEPARTMENT OF NATURAL RESOURCES ON FLICKR

**Landfill site in Wisconsin. The toolkit aims to encourage manufacturers to consider reusability, reparability and recycling at every stage of a product's lifecycle, from design to the point of disposal**

An online resource offering companies a free step-by-step guide to increasing the lifecycle and reusability of their products, thereby making their businesses less environmentally wasteful, has been launched. The Circular Economy Toolkit features various free, downloadable presentations and an assessment tool which enables firms to identify which parts of their businesses are most profligate and least sustainable. Users are then encouraged to develop solutions which, where possible, also increase profit.

The toolkit has been designed by Jamie Evans, a Masters Student at the Department of Engineering's Institute for Manufacturing, with supervision by Dr. Nancy Bocken, as part of wider research into how the economy can become more "circular".

At the moment large sectors of the economy follow a linear model in which limited materials are used to make products which are ultimately disposed of and sent to landfill. "Living on a planet with finite resources means that we cannot afford to keep on throwing materials away - we need to be creative in terms of the ways in which products are designed and components reused at every stage of their lifecycle," Jamie explained.

His research, which fed into the toolkit's design and launch, involved trial workshops with three firms - an electrical goods manufacturer, a company which makes heating equipment and a healthcare provider. In just one of these workshops the group identified 26 opportunities for their business to change its processes to become more environmentally friendly. One such measure was estimated to be worth up to £4million per year to the company, saving 10,000 tons of carbon dioxide.

The core philosophy of the toolkit breaks any product's lifecycle down into six stages - its design, usage, maintenance, re-use, refurbishment and recycling. In addition, the toolkit challenges companies to consider whether their products could be sold as a service, such as collaborative consumption or pay per usage.

Within each of these areas, companies are encouraged to consider whether there is room to improve the product, or the service they offer, to make their business more environmentally sustainable. For example, the design process is analysed to see where material is being wasted, how much is biodegradable, if the materials used are recyclable and other design changes.

The repairability of products is also a major consideration. Even at the design level, the manufacturer is encouraged to take the future refurbishment and maintenance of a product into account, by asking questions such as whether it can be easily dismantled and reassembled, and whether it is set up in such a way that faults can be easily identified.

Users of the toolkit are also asked to consider whether their products can be upgraded rather than replaced, whether they have the potential to be reused second-hand, and whether, once they reach the end of their life, the parts can be recycled. Users are then directed to examples showing how other companies are already generating profit by changing their products and services, the benefits expected and the considerations required.

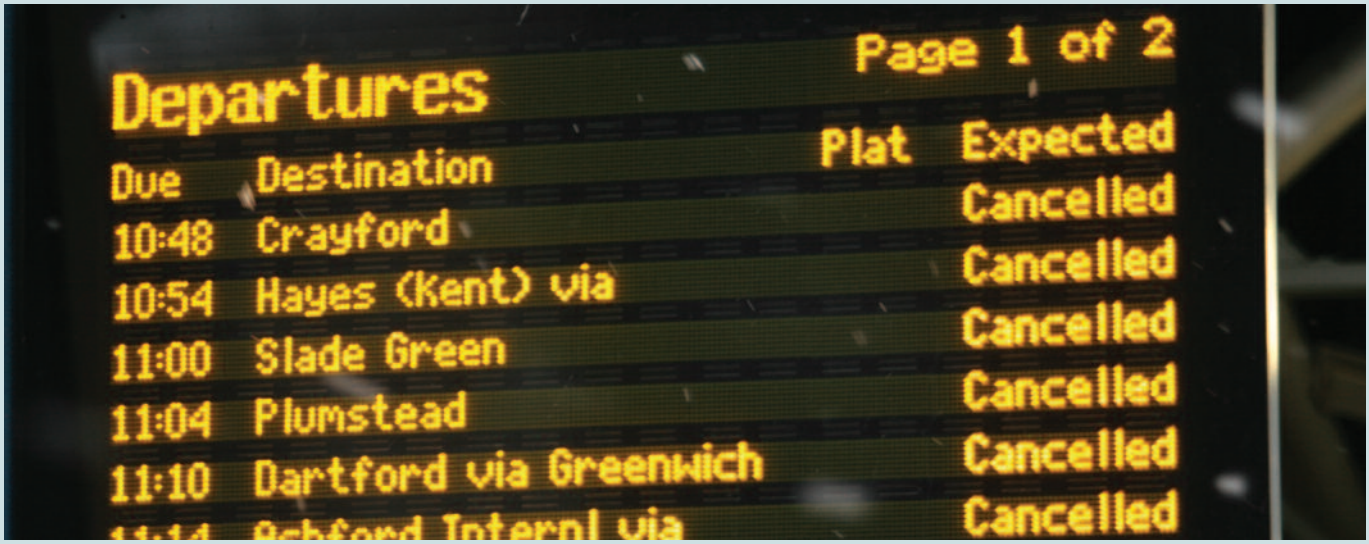
The website features a five minute assessment tool, which allows any manufacturer or retailer to enter information about their product in each of the six lifecycle stages. The site also features all the materials needed for businesses to run their own workshops, analysing their products and services and examining ways in which they can be improved.

***"Living on a planet with finite resources means that we cannot afford to keep on throwing materials away."***
**Jamie Evans**

**www.circulareconomytoolkit.org**

# Engineering the Future

## What do engineers do? More precisely, what do schoolchildren think they do?

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It's an important question because the UK is in need of more engineers to reboot the economy and the UK's manufacturing industry.

The Government's new industrial policies rely on there being a healthy supply of engineers, something that is particularly true for the 'high value' manufacturing areas based on emerging technologies. But is being an engineer something that many schoolchildren list when they are asked what they want to be when they grow up?

Dr Tim Minshall, a senior lecturer in technology management in the Department of Engineering, is passionate about his profession, but he says he was surprised when he went into a UK primary school and asked a group of 10 year olds to draw him some pictures of engineers. Most of the pictures depicted men fixing cars. Others showed men fixing trains. "The only time many people see the word 'engineering' is when there are delayed trains and bus replacement services," he told an audience at the Hay Festival last summer.

Tim says the shortage of engineers and children's perceptions of the profession are linked. "The UK needs more engineers, but engineering is not a thing that young people aspire to be - and this stems from them not really knowing what engineers do. Their perceptions seem to be inaccurate and negative."

His experience in the UK school made him wonder whether this was specifically a UK phenomenon. He spoke to his colleagues who come from a broad range of countries and they suggested doing the 'drawing test' in their countries, using a coding system designed to help researchers understand how young students' perceptions of engineering, engineers, and the work of engineers evolve and are impacted by interventions. The coding system (developed by researchers at Purdue University in the US) aims to provide a standalone measure that can be broadly applied to diverse populations and to create a large multi-institution student database. The idea was that the results could be compared and, if appropriate, used to help inform policymakers in the UK.

> ***"The only time many people see the word 'engineering' is when there are delayed trains and bus replacement services."***
> **Tim Minshall**

At the Hay Festival, Tim unveiled some of the results from Italy. They also depicted people fixing things, but many drew rather glamorous female engineers directing people on building sites.

So far, the project has included a pilot in the UK, data from Italian schools acquired through an academic visitor from Milan and from Germany via an academic visitor from RWTH Aachen University. Later this year, data will be captured and analysed from schools in China and Japan. In the meantime, he has been talking to children around the UK and attempting to counter the myths and enthuse them about what a career in engineering might involve.

At the Hay Festival he summarised what engineers do in 10 words, from inventing to shaping, building to making mistakes and learning from them to, yes, fixing things – although not just cars and trains. "Engineers fix the world and we need more young people in engineering to solve the problems we face," he said.

His talk ranged from Da Vinci's sketches of a helicopter to Sikorsky's engineering brilliance which made the concept work. It covered solar racing cars, upside down cups for babies which never spill, Rolls-Royce jet engines which are specially designed to limit any damage caused by a broken blade to a competition to race a driverless car across the desert, the evolution of mobile phones and development of 3D printing.

Tim said that some commentators believed 3D printing could revolutionise manufacturing, allowing people to create objects at home and saving shipping costs from abroad. Low-end 3D printers could also have an important role to play in schools, helping to re-ignite enthusiasm for engineering and manufacturing.

Indeed he and colleagues in the Engineering Department, Judge Business School and Department of Politics and International Studies have recently been awarded funding from the Economic and Social Research Council and the Engineering and Physical Sciences Research Council for a new research project to examine the reality and the potential of digital fabrication for the UK economy. The project will ask how digital fabrication will affect the manufacturing landscape, what impacts this revolution will have on manufacturing in the UK and how UK firms can become global leaders in this new age of digital manufacturing.

Tim, who has created a blog called http://whatengineersdo.info, is not stopping with talks and research. Following his appearance at Hay, he has been soliciting opinions as to whether there is an appetite for a book aimed at enthusing a future generation of engineers. He was also contacted by the producer of CBBC programme *Nina and the Neurons* and put them in touch with his students who were asked how they would explain various engineering concepts to children.

His passion for his subject is clear and, he hopes, contagious.

**www.whatengineersdo.info**

# The shape of things to come

## Researchers are providing a vision for creatively rethinking how the manufacturing industry can perform sustainably in a changing world..

In the late 18th and early 19th centuries, industrialisation swept the globe and changed it forever: humanity mastered the art of transforming the world's raw materials into the 'stuff of the world'. Today, everything around us, from the cars we drive, to the goods we own and the clothes we wear is largely the product of industrial manufacturing.

But industrialisation also had an unintended effect on the global environment – contributing to the increasing burden of carbon emissions, pollution and waste – and it's widely accepted that a new 'green' industrial revolution is urgently needed.

"It's clear that current processes cannot be sustained indefinitely," said Professor Steve Evans. "As well as the environmental effects, the world has a finite amount of natural resources, and current processes are probably only 10% efficient at converting them into usable product."

Evans leads the Engineering and Physical Sciences Research Council (EPSRC) Centre for Innovative Manufacturing, which connects systems engineers and business analysts at Cambridge's EPSRC Centre for Industrial Sustainability with researchers at Cranfield University, Imperial College and Loughborough University. The Centre is funded with £5.7 million from the EPSRC.

Centre researchers work with multinational businesses such as Toyota, Unilever and M&S to develop the knowledge and tools that will help manufacturers navigate their way through the complexities of designing sustainable industrial processes in the long term.

"To live well, experts think that we must be able to manufacture what we need using less than a quarter of the current bio-capacity. What this means is a reduction of 75–90% in how much carbon-based energy and resources our industrial systems currently use," said Evans. "And to achieve this will mean a complete reshaping of how we manufacture."

His vision extends all the way to a future in which factories could have a net positive effect on the environment: "Part of the work we are doing on configurations would suggest that by the 2050s the air and water leaving factories might be cleaner than what's going in. A greater number will either use local materials or grow the materials they use – perhaps as nanostructures or using green chemistry. This will fundamentally change scale and location decisions for factories to the point where they will be so advantageous that people will want them at the end of their street."

Developing ideas of how eco-factories could look in the future is one aspect of the research carried out by the Centre. However, these are long-term visions, and the researchers recognise not only the complexities of change but also that the "window of opportunity for action is rapidly closing." One key focus of their research agenda, therefore, is to understand how industries can improve their efficiency and environmental performance now, without changing current products and processes.

"How can you find out how efficient a factory can be? You just ask common sense questions," said Evans. "We go into the factories to collect examples of sustainable industrial activity, identify new courses of action, and then publish these as case study reports." A database of over 1,000 effective practices in industrial sustainability has been compiled and will be generally available later this year.

> ***"This will fundamentally change scale and location decisions for factories to the point where they will be so advantageous that people will want them at the end of their street."***
> **Professor Steve Evans**

For Toyota, for example, the researchers discovered that significantly better industrial performance is possible through innovative thinking and careful planning without relying on the development of a 'step change'.

Toyota operate nine manufacturing sites in Europe ranging from engine manufacture through to vehicle assembly. "Toyota took the route of developing action plans with challenging targets to reduce environmental impact – recycling waste water, sending zero waste to landfill and so on – and focused on individual aspects of manufacturing to develop best practice. By adopting these principles, they reduced the energy needed to make cars across their European factories by 44% in five years."

"Some factories are noticeably more efficient than others," Evans added. "We want to know why, and whether they are squeezing every last drop from best practice. If not, how much further can they go and what can competitor factories learn from this?"

Other companies studied by the team have focused their steps on improving environmental performance on packaging reduction (Philips), shifting operations from a product-based system to one in which it provides a service (Xerox), and building a new energy-efficient production facility (Adnams brewery).

THE DISTRICT

"Understanding how far you can push current systems is the most urgently needed step. But technological development is also essential to achieve the significant changes in efficiency that we need," said Evans. To help this agenda, the Centre is also looking at the technology needed to manage factories. One software tool they have built – THERM (for THrough-life Energy and Resource Modelling) – models the way that energy, materials and water can flow around factories. "Traditionally, these processes are considered as secondary to modelling production of the product and yet they are integral to approaching sustainability at a factory level."

The THERM project, funded by the Technology Strategy Board, gathered a team of practitioners (Toyota and Airbus), academics (Cranfield University and De Montfort University) and software developers (Integrated Environmental Solutions) to create the software tool, now available to industry. The tool integrates the modelling of manufacturing processes within their environment – the factory building – to identify system-wide opportunities to reduce resource consumption, carbon emissions and waste generated.

"The greatest opportunity to reduce the environmental impact of an industrial system comes about when we consider the system as a whole, because the optimisation of any one part is ultimately constrained by other aspects," explained Evans. He is a member of the Foresight lead expert group that is combining the latest scientific evidence with futures analysis to help policy makers consider the Future of Manufacturing for the Government Office for Science.

Evans and his team believe that this 'systems thinking' approach is crucial. "The evidence we have seen from case studies shows that sub-system approaches can dramatically improve sustainability. But to help future generations meet the needs of humanity within the carrying capacity of the planet it will be important to develop the know-how to enable changes across the whole industrial system. Such a system is likely to look very different from today's global industry. We believe that manufacturing will change its shape."

**http://www.industrialsustainability.org/**

# Simulation tools aim to bridge exclusion gap

**Simulation gloves and glasses which recreate the effects of moderate impairments have been released by researchers, who say that the designers of many everyday products are frustrating millions of customers by failing to take such limitations into account.**

Dr Sam Waller demonstrating his simulation gloves and glasses

A set of gloves and glasses which simulate common physical limitations, like age-related long-sightedness or arthritis, have been released in the hope of getting more designers to think again about the usability of their products.

Researchers at the University of Cambridge's Engineering Design Centre say that millions of people around the country – in particular the ageing, baby-boomer generation – have unnecessary difficulty using everyday products ranging from gadgets and packaging to windows and doors, because of poor design. Addressing these issues would also reduce the costs of social care.

Many baby-boomers only suffer from mild problems, such as long-sightedness or pain and discomfort in their joints. Although these issues are far from unusual, they are rarely taken into account by mainstream manufacturers, builders and designers. Their customers often find a way to "make do" despite their difficulty using the product, but would benefit from simple and inexpensive design changes.

The simulation gloves and glasses, which are on sale from the inclusive design toolkit website (www.inclusivedesigntoolkit.com/tools), allow designers to experience these limitations for themselves, so that they can identify opportunities for design improvements that would help these 'baby-boomers'. The glasses even set a calibrated benchmark, calculated by researchers, which enables the wearer to work out if a product feature has sufficient visual clarity for 99% of the population to be able to see it.

The development of the tools was led by Dr Sam Waller, an inclusive design researcher in Cambridge's Engineering Design Centre, who studies how everyday products can be made and designed to accommodate the diverse abilities of different sectors of the population. His work builds on 10 years collaborative inclusive design research, conducted by Professors John Clarkson and Roger Coleman, and funded by the Engineering and Physical Sciences Research Council.

> ***"Our hope is that mass-market manufacturers will start using these simulation tools during the development of their products in order to better inform the decisions they make."***
> **Sam Waller**

"The attitude among a lot of manufacturers tends to be: 'If I can use it, everyone can," Sam said. The problem is that if I happen to be a typical, male designer, I may well have reasonably good vision. Everyone with better vision than me will be OK, but anyone whose vision is worse may experience frustration or difficulty."

"What we end up with is a large group of people who have to find some way of coping with this, perhaps by asking for help, and would benefit from minor design modifications. That section of the population is largely unaccounted for, and they would benefit hugely if there was a bit more awareness and appreciation of the different levels of ability out there."

Resembling a pair of 3D specs, the simple simulation glasses can be stacked by the wearer to replicate various levels of impairment, reproducing the effects of problems such as cataracts, age-related long-sightedness, or even just having an out-of-date prescription.

Specifically, they pick up on difficulties with the size or contrast of product features that might compromise the user experience for people with moderate eyesight problems. By using them, a designer can tell if such groups will, for example, be able to pick out the power button on an electronic device, or a warning label that has been embossed on to a plastic surface. Sam argues that such problems can often be addressed without any increase in production cost. The solution can be as simple as changing the colour of the plastic used to make a power button, so that it becomes more obvious.

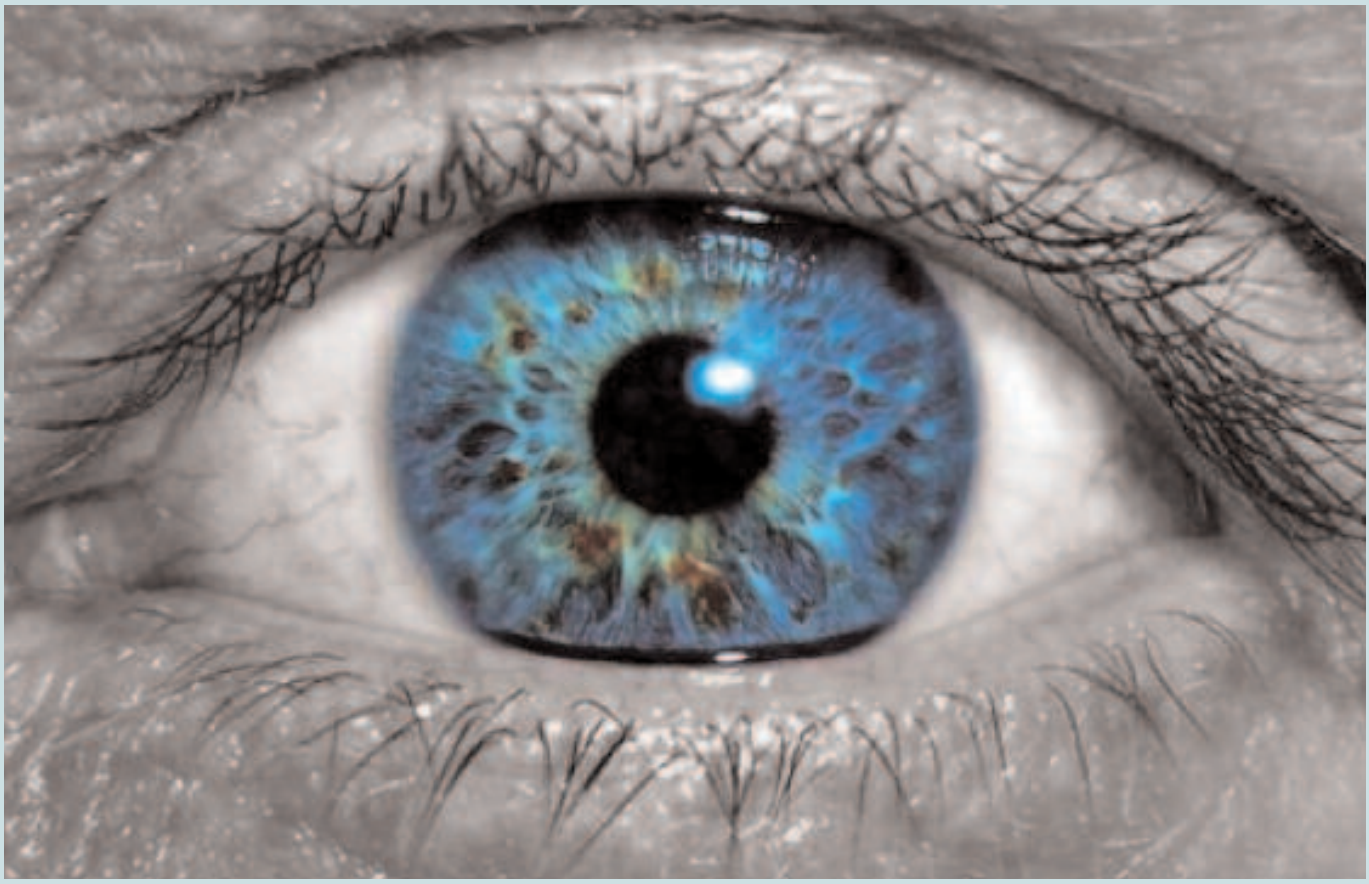
The simulation gloves meanwhile mimic arthritis of the knuckle joints. The more the wearer tries to rotate their joints by bending their fingers, the more they stiffen up, as the plastic skeleton around the gloves puts pressure on the knuckles. They show how this mild limitation can make simple but vital tasks - like opening food packaging – unnecessarily difficult and painful.

"Our hope is that mass-market manufacturers will start using these simulation tools during the development of their products in order to better inform the decisions they make," Sam added. "This enables competitive advantage by improving the user experience, and also reduces social care costs for our ageing society."

**www.inclusivedesigntoolkit.com**

# Cells from the eye are inkjet-printed for the first time

**A group of researchers from Cambridge have used inkjet printing technology to successfully print cells taken from the eye for the very first time.**



DESRAE VIA FLICKR; FATHER OF THE EYE – HDR

The breakthrough could lead to the production of artificial tissue grafts made from the variety of cells found in the human retina and may aid in the search to cure blindness.

At the moment the results are preliminary and provide proof-of-principle that an inkjet printer can be used to print two types of cells from the retina of adult rats – ganglion cells and glial cells. This is the first time the technology has been used successfully to print mature central nervous system cells and the results showed that printed cells remained healthy and retained their ability to survive and grow in culture.

Co-authors of the study, Professor Keith Martin and Dr Barbara Lorber, from the John van Geest Centre for Brain Repair, University of Cambridge, said: "The loss of nerve cells in the retina is a feature of many blinding eye diseases. The retina is an exquisitely organised structure where the precise arrangement of cells in relation to one another is critical for effective visual function.

"Our study has shown, for the first time, that cells derived from the mature central nervous system, the eye, can be printed using a piezoelectric inkjet printer. Although our results are preliminary and much more work is still required, the aim is to develop this technology for use in retinal repair in the future."

The ability to arrange cells into highly defined patterns and structures has recently elevated the use of 3D printing in the biomedical sciences to create cell-based structures for use in regenerative medicine.

In their study, the researchers used a piezoelectric inkjet printer device that ejected the cells through a sub-millimetre diameter nozzle when a specific electrical pulse was applied. They also used high speed video technology to record the printing process with high resolution and optimised their procedures accordingly.

Dr Wen-Kai Hsiao, is a member of the team based at the Department of Engineering's Inkjet Research Centre. He commented: "In order for a fluid to print well from an inkjet print head, its properties, such as viscosity and surface tension, need to conform to a fairly narrow range of values. Adding cells to the fluid complicates its properties significantly."

Once printed, a number of tests were performed on each type of cell to see how many of the cells survived the process and how it affected their ability to survive and grow.

The cells derived from the retina of the rats were retinal ganglion cells, which transmit information from the eye to certain parts of the brain, and glial cells, which provide support and protection for neurons.

"We plan to extend this study to print other cells of the retina and to investigate if light-sensitive photoreceptors can be successfully printed using inkjet technology. In addition, we would like to further develop our printing process to be suitable for commercial, multi-nozzle print heads," Professor Martin concluded.

The research was undertaken by rofessor Martin and Dr Lorber, in collaboration with Dr Wen-Kai Hsiao and Professor Ian Hutchings from the Department of Engineering's Inkjet Research Centre. The work was funded by Fight for Sight, the van Geest Foundation and the Engineering and Physical Sciences Research Council.

***"Our study has shown, for the first time, that cells derived from the mature central nervous system, the eye, can be printed using a piezoelectric inkjet printer."***
**Keith Martin and Barbara Lorber**

**www.ifm.eng.cam.ac.uk/research/irc**