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DEPARTMENT OF ENGINEERING NEWS

UNIVERSITY OF CAMBRIDGE

Welcome

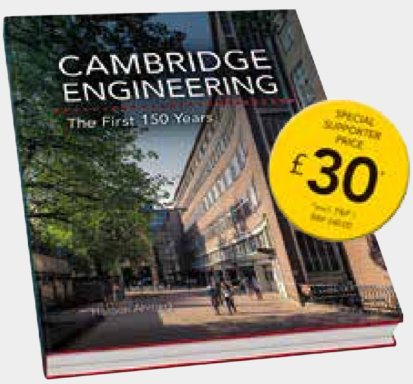
In 1875, James Stuart was appointed Chair of Mechanism and Applied Mechanics, marking the formation of the modern Department of Engineering. From its humble beginnings in a workshop in a wooden hut, Cambridge Engineering has grown immensely. The Department is now the largest within the University of Cambridge, with over 150 academics, 350 researchers, 900 graduate students and 1200 undergraduates.

The next phase is to unite all the various elements onto one site in West Cambridge, replacing our old and scattered building stock with new facilities and support. This plan to Move West will unlock our full potential.

Our forthcoming book, *Cambridge Engineering: The First 150 Years*, will look not only at the past accomplishments of this institution but toward the future. Written by Haroon Ahmed, an Electrical Engineering and Physics lecturer, Master of Corpus Christi College and co-author of the bestselling text *Electronics for Engineers*, the book will give a thoroughly readable account of the Department and its people from before its inception to our plans for the 150th anniversary in 2025. We hope you'll buy this book and share it with family and friends, celebrating this milestone for the Department. If you order early, you'll receive a discount and be recognised in the text as a supporter.

These perspectives on our history and long-term future have not distracted us from the engineering challenges of today. In this newsletter, you will read about Professor Roberto Cipolla's new Segnet system that can identify and classify any street scene with a smartphone. You will read about Dr Yu Jia and Dr Ashwin Seshia's vibration-energy harvesting device that was trialled under the Forth Road Bridge. And you will see the beauty of engineering in striking images from our latest photography competition.

Professor David Cardwell FREng



Cambridge Engineering
The First 150 Years

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In this issue

Cover image: a head-up display projects key driving information onto a small area of the windscreen. Credit: Jaguar Land Rover

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Credit: Alex Kendall

New smartphone-based system teaches machines to see

Two technologies which use deep learning techniques to help machines to see and recognise their location and surroundings could be used for the development of driverless cars and autonomous robotics – and can be used on a regular camera or smartphone.

Two newly-developed systems for driverless cars can identify a user's location and orientation in places where GPS does not function, and identify the various components of a road scene in real time on a regular camera or smartphone, performing the same job as sensors costing tens of thousands of pounds.

The first system, called SegNet, can take an image of a street scene it hasn't seen before and classify it, sorting objects into 12 different categories – such as roads, street signs, pedestrians, buildings and cyclists – in real time. It can deal with light, shadow and night-time environments, and currently labels more than 90% of pixels correctly. Previous systems using expensive laser or radar-based sensors have not been able to reach this level of accuracy while operating in real time.

Users can visit the SegNet website and upload an image or search for any city or town in the world, and the system will label all the components of the road scene. The system has been successfully tested on both city roads and motorways.

In contrast with expensive sensors, which recognise objects through a mixture of radar and LIDAR (a remote sensing technology), SegNet learns by example – it was 'trained' by an industrious group of Cambridge undergraduate students, who manually labelled every pixel in each of 5000 images, with each image taking about 30 minutes to complete. Once the labelling was finished, the researchers then took two days to 'train' the system before it was put into action.

"It's remarkably good at recognising things in an image, because it's had so much practice," said Alex Kendall, a PhD student in the Department of Engineering. "However, there are a million knobs that we can turn to fine-tune the system so that it keeps getting better."

The system is not yet at the point where it can be used to control a car or truck, but it could be used as a warning system, similar to the anti-collision technologies currently available on some passenger cars.

"Vision is our most powerful sense and driverless cars will also need to see," said Professor Roberto Cipolla, who led the research. "But teaching a machine to see is far more difficult than it sounds."

As children, we learn to recognise objects through example – if we're shown a toy car several times, we learn to recognise both that specific car and other similar cars as the same type of object. But with a machine, it's not as simple as showing it a single car and then having it be able to recognise all different types of cars. Machines today learn under supervision: sometimes through thousands of labelled examples.

The localisation system designed by Kendall and Cipolla is able to localise a user and determine their orientation from a single colour image in a busy urban scene. The system is far more accurate than GPS and works in places where GPS does not, such as indoors, in tunnels, or in cities where a reliable GPS signal is not available.

"In the short term, we're more likely to see this sort of system on a domestic robot – such as a robotic vacuum cleaner, for instance," said Cipolla.

Roberto Cipolla

www.eng.cam.ac.uk/profiles/rc10001
www.eng.cam.ac.uk/profiles/agk34
www.youtube.com/watch?v=MxximR-1In4

Students visit Crossrail Liverpool Street station and tunnels site

A group of fourth year undergraduate engineering students recently visited the Crossrail Liverpool Street station and tunnels site in London.

The students were asked to write an essay on the sustainability considerations of a major civil engineering infrastructure project, and this group of students each chose to write about Crossrail, Europe's largest underground construction project.

Crossrail is a major new cross-London rail link project stretching from Reading and Heathrow in the west, across to Shenfield and Abbey Wood in the east. The scheme aims to improve travel across London, provide better connections and ease congestion. Liverpool Street station is undergoing major redevelopment to increase capacity, improve accessibility and upgrade interchanges as part of the building of Crossrail.

Ravi Kuganathan (Laing O'Rourke Project Engineer for Tunnels and Platforms) and Mark Bennett (Laing O'Rourke Construction Manager) took the students for a walk around the site of the future Liverpool Street ticket entrance, including foundation works and excavations of 25 metres to accommodate escalators that will connect with the station platforms as well as deep underground into the newest additions to London's vast tunnelling network. They were then able to talk to Joel Harland, who is currently on a graduate scheme, about his role on the project and his experience in industry since graduation.

Visits such as this provide students with an opportunity to understand how they can use what they have learnt on the Department undergraduate course to work on exciting construction projects whilst understanding their impacts on society as engineers. This particular trip was organised by Sakthy Selvakumaran, a Department of Engineering graduate and current PhD student who has gone on to work in different design, delivery and R&D roles for the Crossrail project. She provides an example of where a career that started off in the Department of Engineering can take students.

The Sustainable Development Module aims to develop the students' understanding of the wider issues relating to sustainable development with respect to implementation. Having done research and read about the project and various initiatives taken by Crossrail, the students were invited to visit the Liverpool Street station and tunnels live site, and chat to staff currently working on the scheme about their role, site activities and the wider implications of the Crossrail scheme.

In the students' own words:

"The tour of the Liverpool Street site of Crossrail was fascinating, and really got me thinking about the sheer scale of the engineering challenge that Crossrail presents. Opportunities to see Europe's largest construction project are rare, and so I really valued the opportunity to see the engineering behind the project."

Fourth-year undergraduate Chris Chasty

"It was only when I descended into the vast tunnels that I was finally able to appreciate the sheer scale of the project.

"I was struck by the pervasive adoption of sustainability practices which extended from the site offices to the tunnels tens of meters below."

Fourth-year undergraduate Jimi Oluwole

"I found the experience really interesting, especially hearing directly from staff working on Crossrail about their work, giving a human face to the sustainability report we're reading."

Fourth-year undergraduate Sarah Wong

Sakthy Selvakumaran

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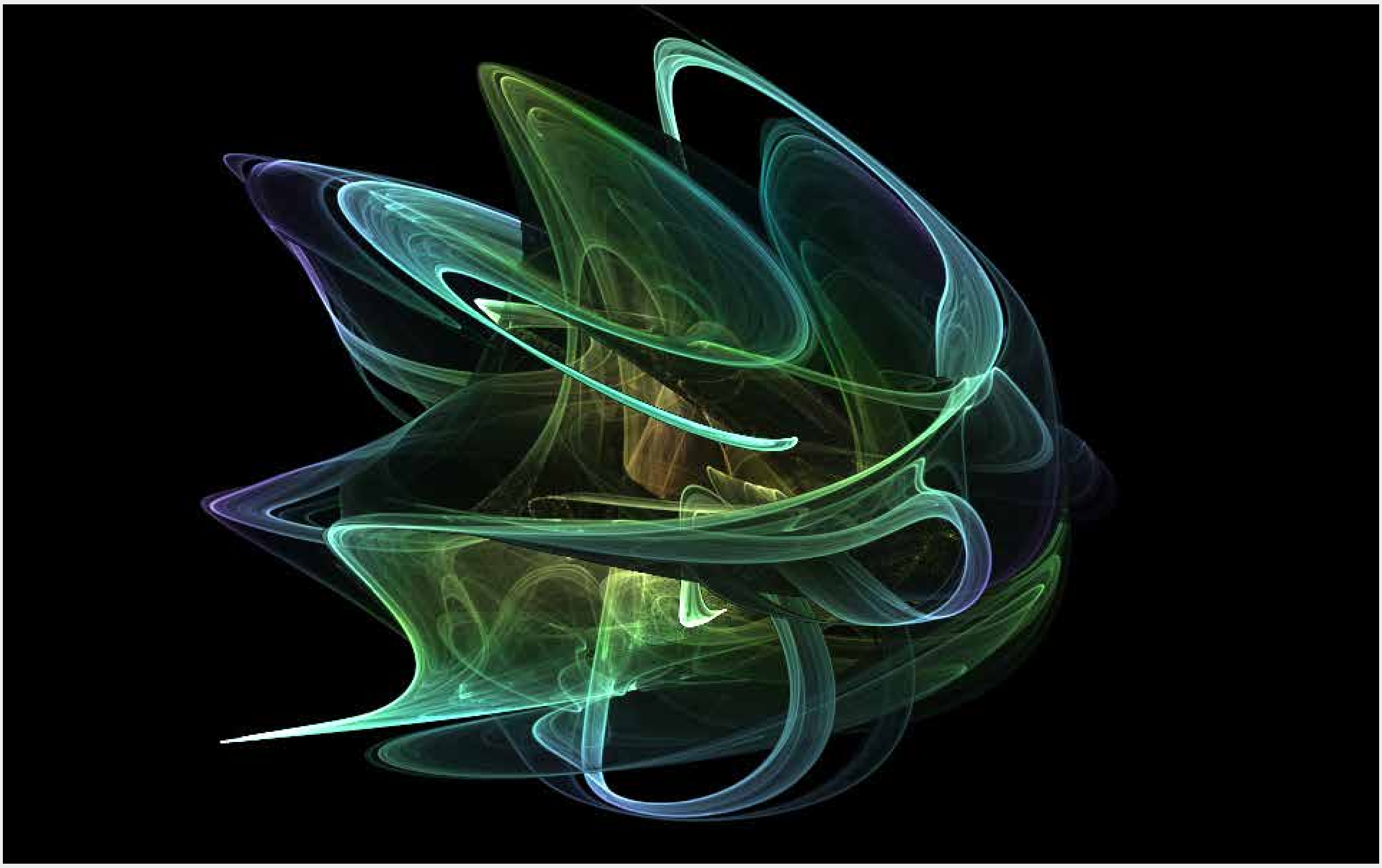

Credit: Tom Rainforth

On switchlets and sensory systems

↑ Pickover attractor

Professor Rodolphe Sepulchre of the Control Group has received a €2.5 million grant from the European Research Council (ERC) to advance his work on the topic of switchlets.

Switchlets are a novel development in control theory and are analogous to the concept of wavelets in the field of signal processing. Switchlets are a way to model systems that can generate and modulate complex, multiscale signals, such as those from the brain which are signals composed of several different temporal and spatial frequencies.

As Professor Sepulchre explained, it is a difficult problem to sort out a broad mixture of frequencies. In signal processing, wavelets – single oscillations resembling waves – are used to deconstruct these frequency mixtures. His approach is to take this same concept and apply it to systems, which can potentially impact control theory, machine learning and neuroscience.

A particular focus of Professor Sepulchre's research is to emphasise the role of feedback in modulating the resolution of systems. The human visual system, for example, works on many layers. Some are responsible for the small details within an image, and some take a scene as a whole. The brain's job is to adapt to the various scales and interpret them quickly, and artificial systems have thus far struggled with this problem. "This is a general challenge in the age of big data," Sepulchre said. "We collect so much data at the same resolution, but in fact we need very little of it. We develop more and more systems to extract information from more and more data, but it's not done in a multiresolution way.

"We forget what we memorise, we disregard what we see, and often we don't listen to what we hear … Machines are quite bad at discerning, and this makes our brain fast, in fact much faster than computers at zooming in and zooming out on the relevant information."

That's where switchlets come in – they will enable new sensory systems that have the capacity to interpret at the multiscale and bridge the fields of engineering and neuroscience.

Professor Sepulchre is planning a workshop in Cambridge next year to bring control engineers and neuroscientists together, continuing the collaboration and exploring the shared direction of their fields.

Professor Sepulchre spoke on the ways that human brains compute during a TEDx talk in Liège, Belgium. A link to the video is below.

> We collect so much data at the same resolution, but in fact we need very little of it.
>
> Rodolphe Sepulchre

Rodolphe Sepulchre

www.youtube.com/watch?v=OXoJJX3GOaQ
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Eddie Lacy (cropped)

New origami-like material may help prevent brain injuries in sport

Researchers are developing the next generation of advanced materials for use in sport and military applications with the goal of preventing brain injuries.

A team including researchers from Cambridge and Cardiff Universities is developing an origami-like material that could help prevent brain injuries in sport, as part of a programme sponsored in part by American football's National Football League (NFL).

Working in collaboration with helmet designer and manufacturer Charles Owen Inc, and with additional support from GE Health care, Under Armour and the National Institute of Standards and Technology, the team will develop and test their materials over the next 12 months.

The NFL's Head Health Challenge, a $20 million collaborative project to develop new and innovative technologies in order to improve early-stage detection of mild traumatic brain injuries and to improve brain protection, aims to improve the safety of athletes, members of the military and society overall.

"The key challenge for us is to come up with a material that can be optimised for a range of different types of impacts," said Dr Graham McShane of the Department of Engineering, who is part of the team behind the material. "A direct impact is different than an oblique impact, so the ideal material will behave and deform accordingly, depending on how it's been hit – what we are looking at is the relationship between the material, geometry and the force of impact."

In high-impact sports such as American football, players can hit each other with the equivalent of half a ton of force, and in an average game, there can be dozens of these high-impact blocks or tackles. More than 100 concussions are reported each year in the NFL, and over the course of a career, multiple concussions can cause serious long-term damage.

The multi-layered, elastic material developed by McShane and his colleagues at Cambridge and Cardiff, called C3, has been designed and tested using a mixture of theoretical and experimental techniques, so that it can be tailored for specific impact scenarios.

C3 has its origins in cellular materials conceived in the Department of Engineering for defence applications, and is based on folded, origami-like structures. It is more versatile than the polymer foams currently used in protective helmets, which are highly limited in terms of how they behave under different conditions.

Structures made from C3 can be designed in such a way that impact energy can be dissipated relatively easily, making it an ideal material to use in protective clothing and accessories.

Dr Peter Theobald, a Senior Lecturer at Cardiff University who is leading on the project, said: "Head injury prevention strategies have remained relatively stagnant versus the evolution of other technologies. Our trans-Atlantic collaboration with Charles Owen Inc. has enabled us to pool our highly relevant skills and expertise in injury prevention, mechanics, manufacturing and commercialisation."

"This approach has already enabled us to develop C3 which, in the words of our evaluators, presents a potentially 'game-changing' material with which to better absorb the vertical and horizontal components of an oblique impact. This highly prestigious award provides us with a platform to continue developing C3 in order to achieve our ultimate goal of a material that provides a step-change in head health and protection, whilst achieving metrics that ensure commercial viability."

> "The key challenge for us is to come up with a material that can be optimised for a range of different types of impacts.
>
> Graham McShane

Graham McShane

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ALUMNI UPDATE

Alumna Helen Cavill wins Women's Engineering Society Prize

The winner of the Institution of Engineering and Technology (IET) Young Woman Engineer of the Year Award 2015 was alumna Helen Cavill, Process Improvement Manager at M&H Plastics.

Helen graduated from the Department's Manufacturing Engineering Tripos in 2009 and became a Chartered Engineer in 2014. Since graduation, she has held the role of Process Improvement Manager at M&H Plastics in Suffolk.

M&H Plastics is a premium manufacturer of plastic bottles and caps, primarily for the personal care market. Helen's role involves investigating and resolving complex technical issues, often spanning across several production departments (a challenge that she describes as being an "engineering detective"), as well as leading long-term improvement projects. Currently, Helen is working on optimisation of Ultra Violet ink curing and automated dimensional measuring of plastic components.

For the last nine years, Helen has been a Science, Technology, Engineering and Mathematics (STEM) Ambassador (something she first became involved in through the Department's outreach programme), reaching the final of the 2013 STEMNET Most Dedicated Ambassador Award. She particularly enjoys volunteering on activities where her creativity and design skills can be exercised to devise novel educational resources. In addition to running Saturday Science Masterclasses, Helen has been on the organising committee of the Lowestoft Interschool Maths Challenge every year since its inception, designing and building three-dimensional practical maths games suitable for teams consisting of a wide range of ages.

Helen talks about her time studying at Cambridge and how it has stood her in good stead for a career in manufacturing: "The combination of two years of General Engineering followed by the Manufacturing Engineering Tripos (MET) has been excellent preparation for my career. In fact, the MET course content was so comprehensive that for the first few years after graduation I had to keep turning down opportunities to go on courses because I realised that I had already covered the material during my degree.

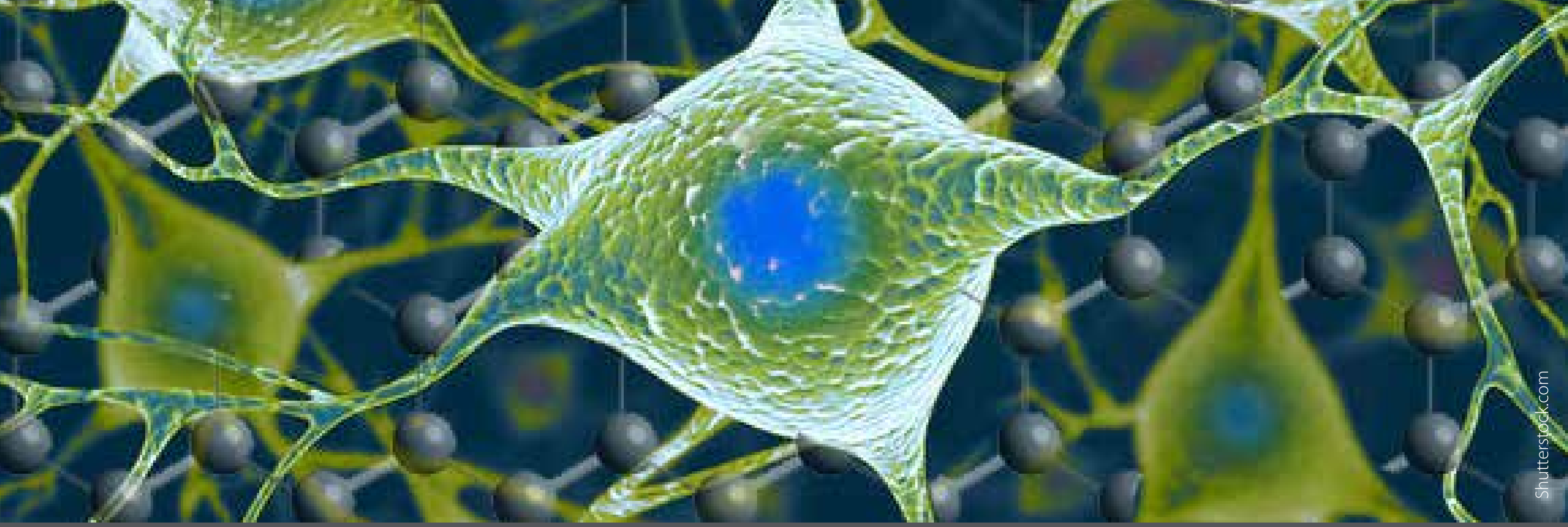
"The General Engineering aspects have been invaluable in interacting with colleagues and suppliers, and my first year lecture notes have re-emerged on several occasions when calculations were required (often to work out how on earth someone managed to snap part of a machine in half!); although the fact my factory does not operate in a frictionless vacuum does require a little extra thought at times. I quickly learnt that the key is not to remember everything, but to remember that you have comprehensive notes about that topic in a folder somewhere (and preferably remember where the folder is).

"MET was the perfect course for me – combining technical knowledge and practical group activities with first-hand exposure to countless different industries. The fourth year industrial projects were particularly beneficial in learning how to work in a team under pressure, how to extract information from different stakeholders and what to do when there are conflicting views or general lack of enthusiasm from the factory floor. These projects further helped develop communication and presentation skills, plus the need to be flexible and think on your feet. Refining these skills has helped me excel in my job – I am now confident presenting findings to company directors, leading training courses or delivering a speech to hundreds of people.

"As Process Improvement Manager, I need a strong technical aptitude and attention to detail, but also excellent people skills. I can rarely solve production problems just by inspecting the bottles – there is usually a critical piece of information that needs to come forward from the people around me. The MET course has definitely helped me to progress the softer skills and emotional intelligence that make me so effective at my role.

"I will always have the prestige of being able to say that I am a Cambridge University graduate, but more importantly I feel that I am truly reaping the benefits of my education every day."

www.wes.org.uk
www.eng.cam.ac.uk/events-and-outreach/events-and-outreach-overview



Graphene shown to interact safely with neurons in the brain

Researchers have successfully demonstrated how it is possible to interface graphene – a two-dimensional form of carbon – with neurons, or nerve cells, while maintaining the integrity of these vital cells. The work may be used to build graphene-based electrodes that can safely be implanted in the brain, offering promise for the restoration of sensory functions for amputee or paralysed patients, or for individuals with motor disorders such as epilepsy or Parkinson's disease.

The research, published in the journal *ACS Nano*, was an interdisciplinary collaboration coordinated by the University of Trieste in Italy and the Department of Engineering's Cambridge Graphene Centre.

Previously, other groups had shown that it is possible to use treated graphene to interact with neurons. However the signal-to-noise ratio from this interface was very low. By developing methods of working with untreated graphene, the researchers retained the material's electrical conductivity, making it a significantly better electrode.

"For the first time we interfaced graphene to neurons directly," said Professor Laura Ballerini of the University of Trieste in Italy. "We then tested the ability of neurons to generate electrical signals known to represent brain activities, and found that the neurons retained their neuronal signalling properties unaltered. This is the first functional study of neuronal synaptic activity using uncoated graphene based materials.

"Our understanding of the brain has increased to such a degree that by interfacing directly between the brain and the outside world we can now harness and control some of its functions. For instance, by measuring the brain's electrical impulses, sensory functions can be recovered. This can be used to control robotic arms for amputee patients or any number of basic processes for paralysed patients – from speech to movement of objects in the world around them. Alternatively, by interfering with these electrical impulses, motor disorders (such as epilepsy or Parkinson's) can start to be controlled.

Scientists have made this possible by developing electrodes that can be placed deep within the brain. These electrodes connect directly to neurons and transmit their electrical signals away from the body, allowing their meaning to be decoded.

Based on experiments conducted in rat brain cell cultures, the researchers found that untreated graphene electrodes interfaced well with neurons. By studying the neurons with electron microscopy and immunofluorescence the researchers found that they remained healthy, transmitting normal electric impulses. Importantly, none of the adverse reactions which lead to the damaging scar tissue were seen.

According to the researchers, this is the first step towards using pristine graphene-based materials as an electrode for a neuro-interface. In future, the researchers will investigate how different forms of graphene, from multiple layers to monolayers, are able to affect neurons, and whether tuning the material properties of graphene might alter the synapses and neuronal excitability in new and unique ways. "Hopefully this will pave the way for better deep brain implants to both harness and control the brain, with higher sensitivity and fewer unwanted side effects," said Ballerini.

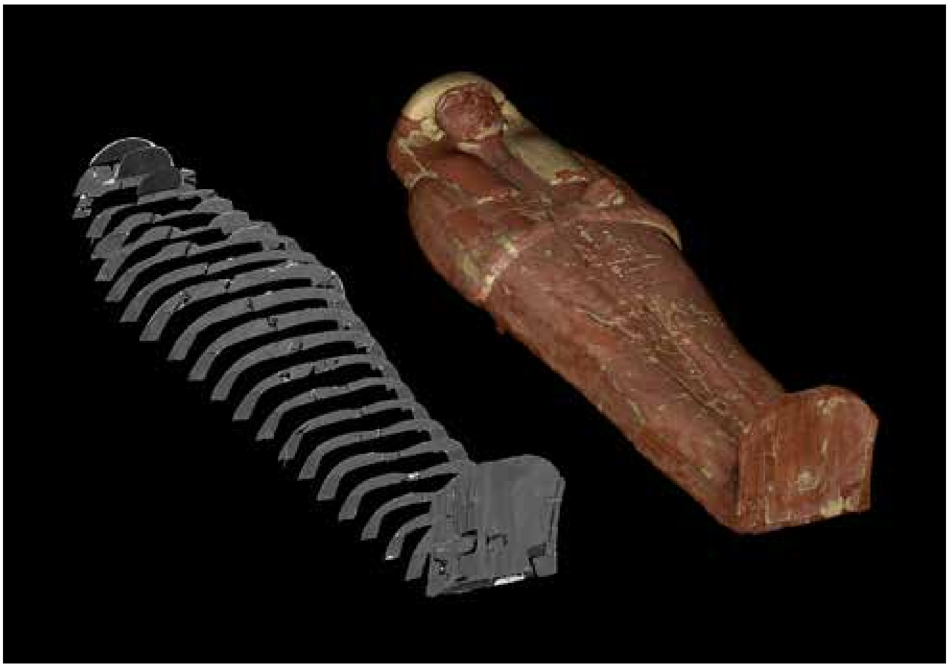
"These initial results show how we are just at the tip of the iceberg when it comes to the potential of graphene and related materials in bio-applications and medicine," said Professor Andrea Ferrari, Director of the Cambridge Graphene Centre. "The expertise developed at the Cambridge Graphene Centre allows us to produce large quantities of pristine material in solution, and this study proves the compatibility of our process with neuro-interfaces."

The research was funded by the Graphene Flagship, a European initiative which promotes a collaborative approach to research with an aim of helping to translate graphene out of the academic laboratory, through local industry and into society.

Andrea Ferrari

www.eng.cam.ac.uk/profiles/acf26
www.graphene.cam.ac.uk

→ Nespawershefyt inner coffin lid volume rendering alongside individual cross section cuts



Credit: Tom Turmezei

Seeing inside ancient Egypt

A researcher used medical imaging techniques to discover the secrets behind Egyptian artefacts in the Fitzwilliam Museum's *Death on the Nile* exhibition.

The exhibition, which opened on 23 February, explores how coffin design developed over 4,000 years of Egyptian history. To better understand their construction, the Museum contacted Dr Tom Turmezei of the Medical Imaging Group, part of the Machine Intelligence Laboratory. He looked at the coffins of Nespawershefyt and Nakhtefmut, both important officials at the temple of Amun-Re at Karnak. The former was a supervisor of temple scribes and of craftsmen's workshops circa 1000BC, and the latter responsible for opening the doors of the shrine that contained the figure of Amun-Re in the innermost sanctuary of the temple circa 923BC.

Visual inspection of the coffins can only tell so much. Working with the Department of Radiology at Addenbrooke's Hospital, where he is also an honorary consultant radiologist, Tom helped subject the coffins to computerised tomography (CT) scanning. This technique uses X-rays to compile a set of cross-sectional images of an object which can be rendered into a 3D model of the insides. This enabled Tom to effectively see within the coffins and get a sense of their internal structures.

"Being able to visualise the inner craftsmanship and construction of these wooden coffins can help provide Egyptologists with valuable insights into the work practices and customs of the time," Tom said. "We already knew that a lot of wood was recycled for these coffins because of its scarcity, but we now also know a little bit more of just exactly how this was done. Hopefully the imaging also provides an exciting visual medium for the public to appreciate and explore these remarkable artefacts from their inside, in addition to their stunning surface detail."

The same techniques were previously used by Dr Turmezei to see inside 18th- and 19th-century artists' mannequins for another exhibition at the Fitzwilliam called 'Silent Partners.'

↑ Full length view of coffin from the coffin set of Nespawershefyt ©The Fitzwilliam Museum, Cambridge

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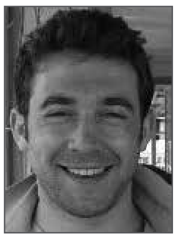
Being able to visualise the inner craftsmanship and construction of these wooden coffins can help provide Egyptologists with valuable insights into the work practices and customs of the time.

Tom Turmezei



Tom Turmezei

www.eng.cam.ac.uk/profiles/tdt21

Nanotech research fellow amasses honours

Since joining the Department, Dr Matt Cole, Oppenheimer Research Fellow in the Centre for Advanced Photonics and Electronics, and Fellow of St Edmund's College, has made significant achievements in research, industry, teaching and outreach.

After graduating in Engineering Science at the University of Oxford and performing research at Harvard University, Cole completed his PhD in flexible electronics under Professor Bill Milne in 2011. Now his work focuses on carbon nanotubes and graphene nanomaterials, including their synthesis, alignment and their integration into nanocarbon-based field electron emission devices.

Alongside Professor Milne, Dr Jonathan Cameron and Richard Parmee, Cole founded the spinout company Cambridge Xray Systems, a company which aims to commercialise the team's ongoing research on the development of nanomaterial-based X-ray sources. "The company is very much an outlet for the various devices we have developed in the lab," Matt said. "These emerging nanoscale materials afford a degree of manufacturability and functionality not yet seen in other material platforms".

Cole's enthusiasm for science and technology plays into the breadth of activities with which he is engaged, in particular his outreach and teaching. He is a College Teaching Officer, Admissions Tutor and Director of Studies (DoS) in Engineering at St Edmund's College. He is a passionate Science, Technology, Engineering, and Maths (STEM) Ambassador, working with STEM Team East, a group dedicated to promoting science education to young people. "My outreach work and teaching are very rewarding," Matt said. "Here at Cambridge, as DoS, I guide a handful of undergraduates at St Edmund's through the challenging Engineering Tripos. Going out to STEM events is very different – you might talk to two, three hundred students. It's a great opportunity to connect the wider public with your research."

In 2015 Cole was the recipient of several prestigious awards and honours. He received the 2015 Institution of Engineering and Technology (IET) Sir Henry Royce Medal for his research on nanomaterials and the production of novel X-ray sources; the Institute of Materials, Minerals and Mining (IOM3) Silver Medal, given to younger researchers for contributions to materials science; and the Royal Academy of Engineering Sir George Macfarlane Medal, for his work in nanoscale materials science. Commenting on the awards, Matt said: "I am very honoured indeed. It's an absolute privilege to be recognised by such leading Institutions".

2016 has seen a similarly shining start, with Cole's listing in Forbes magazine's '30 Under 30'. Featuring Europe's top young leaders, creative inventors and entrepreneurs, Cole was listed in the Science and Healthcare category for his role in founding Cambridge Xray Systems.

> I am very honoured indeed. It's an absolute privilege to be recognised by such leading institutions.
>
> Matt Cole

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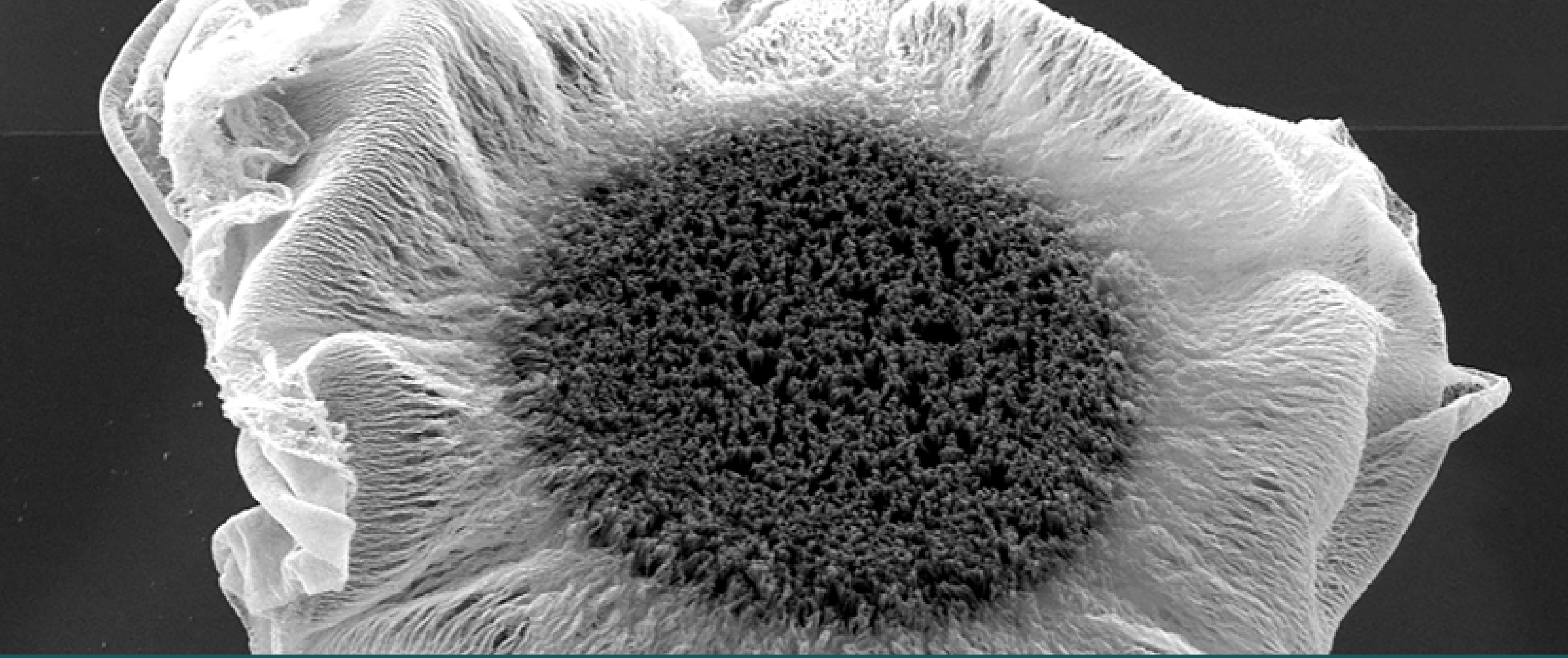

Small but mighty

The manufacturing challenges of nanotechnology

Head of NanoManufacturing at the Institute for Manufacturing (IfM) Dr Michaël de Volder explains why manufacturing carbon nanotubes is so difficult – and so important.

While much hype has arisen around 'two-dimensional' graphene, carbon nanotubes – rolled up sheets of graphene – have been quietly stealing a march. In fact, carbon nanotubes have been with us a lot longer. We know that hollow carbon nanofibres were observed as far back as the 1950s and researchers have been actively researching carbon nanotubes since the early 1990s. As a result, the manufacturing techniques for carbon nanotubes are comparatively mature, with several thousand tons being produced each year – unlike high quality graphene which is still very difficult to manufacture in large quantities. We understand how to make carbon nanotubes and can do so in relatively large quantities.

What we now need to learn is how to structure and organise them in such a way that they retain their properties when assembled into a device. And this, to a large extent, is a manufacturing challenge. At the moment, most carbon nanotube products are processed using traditional manufacturing techniques, such as injection moulding of carbon nanotube -polymer composites which do not give us any structural control over how the nanoparticles are arranged – and limit the material properties they can deliver. By developing new technologies which allow us to make devices containing well-organised nanoparticles we should be able to achieve a dramatic improvement in their performance and open up a whole raft of new application possibilities.

This is exactly what the IfM's zanoManufacturing Group is trying to do. The team was founded just two years ago and is itself a demonstration of rapid scale up, with five engineers, four chemists, two physicists and two material scientists already in post. The nanomanufacturing challenge is such a complex one that we need a multidisciplinary team to address it, as well as the collaboration of other universities, a broad spectrum of industries, and closer to home, collaborators in the Departments of Engineering, Materials Science, Chemistry, Chemical Engineering, and the Cavendish Laboratory. We also work very closely with other research centres at the IfM which are similarly engaged in developing new advanced materials and manufacturing processes.

The IfM's NanoManufacturing Group is also focusing on the development of technologies which can organise nanoparticles into hierarchical superstructures. To achieve this, we are researching how to simultaneously optimise material properties at three length scales: at the nanoscale on surface chemistry, at the microscale on form and structure and at the large scale to integrate the particles into devices. With funding from the European Research Council, the European Union's Marie Curie scheme and the EPSRC, the Group is exploring new ways of fabricating such carbon nanotube-based devices by, for instance, combining lithography with chemical engineering techniques.

The promise of nanotechnology is such that billions of dollars of public money have been and continue to be spent on research by national governments. We are now reaching a tipping point where we understand the physical properties of many nanoparticles and how to produce them sufficiently well to start them on their journey to commercialisation. Indeed, it may come as a surprise to learn that carbon nanotubes are already being used commercially in a variety of products ranging from sporting goods and batteries to cars and bullet proof vests. This is only the beginning: we will soon see these small but mighty structures being put to many different uses.

> There are still major challenges to overcome before carbon nanotubes can really start to fulfil their potential.
>
> Michaël de Volder

Michaël de Volder

www.ifm.eng.cam.ac.uk
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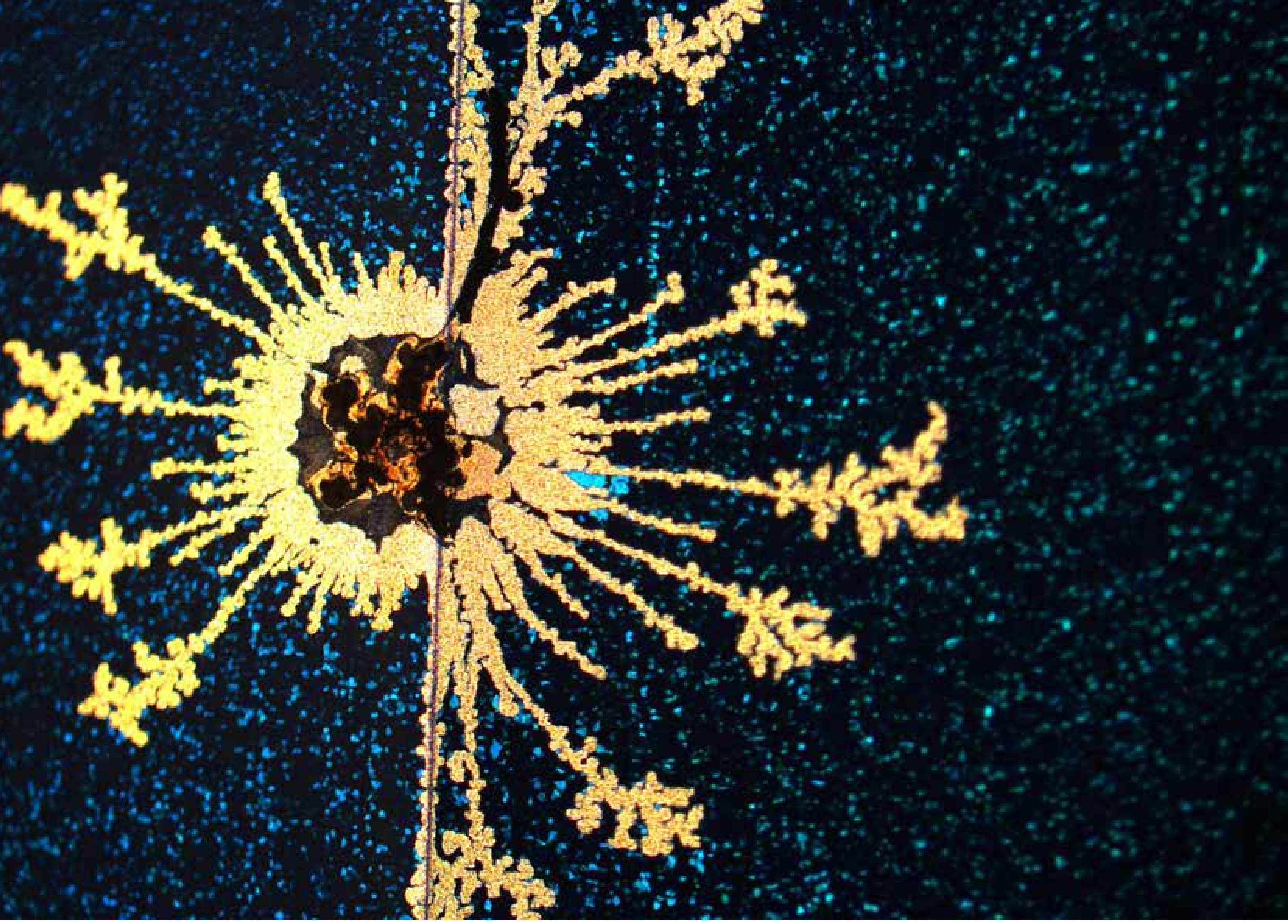


Bullet holes and graphene caves

Picturing engineering

↑ **First prize. Rachel Garsed, *Shot in the Dark*.**

From a Cambridge guide for robot tourists, to titanium 'comets', the winners of the annual Department photo competition highlight the variety and beauty of engineering.

For many people, engineering conjures up images of bridges, tunnels and buildings. But the annual University of Cambridge engineering photo competition shows that not only is engineering an incredibly diverse field, it's a beautiful one too.

The annual competition showcases the breadth of engineering research at the University, from objects at the nanoscale all the way to major infrastructure. The winning images can be viewed on the Engineering Department's website from today, alongside dozens of other entries.

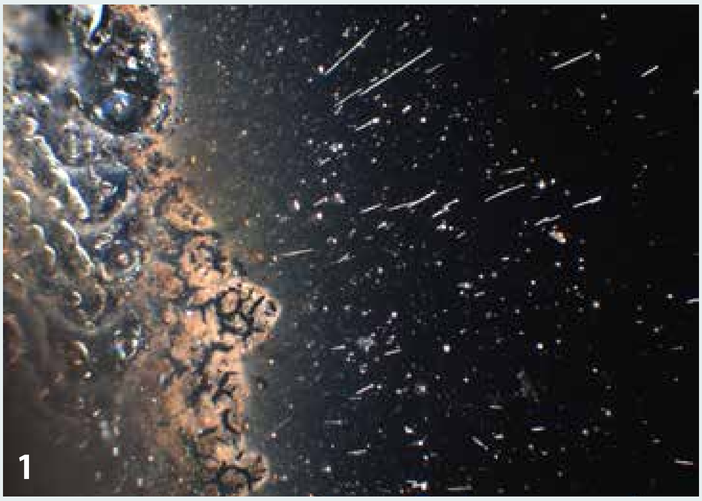
The competition, sponsored by ZEISS, international leaders in the fields of optics and optoelectronics, had five categories this year: alongside those for first, second and third place, the ZEISS SEM prize was awarded for a micrograph captured using an electron microscope, and a Head of Department's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

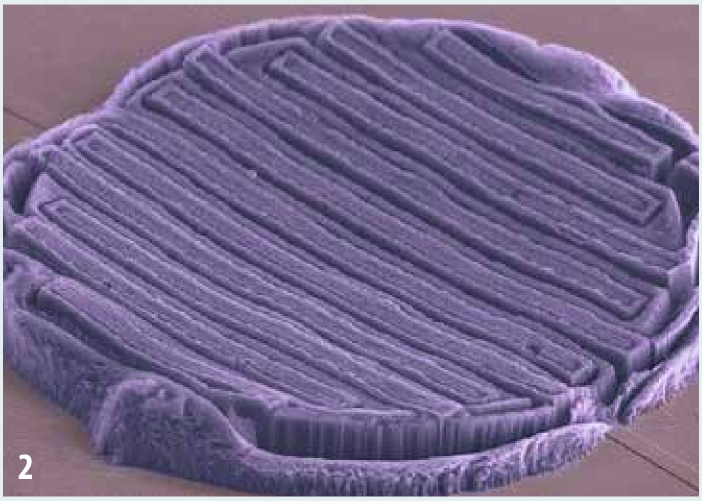
First prize went to Rachel Garsed for her image of a bullet hole pattern in a liquid crystal, while second prize went to Andrew Payne for his image of a titanium 'comet'. Other winners included Dilek Ozgit and Andrea De Luca's image of carbon nanotubes and Kenichi Nakanishi's image of cave-like formations made from graphene.

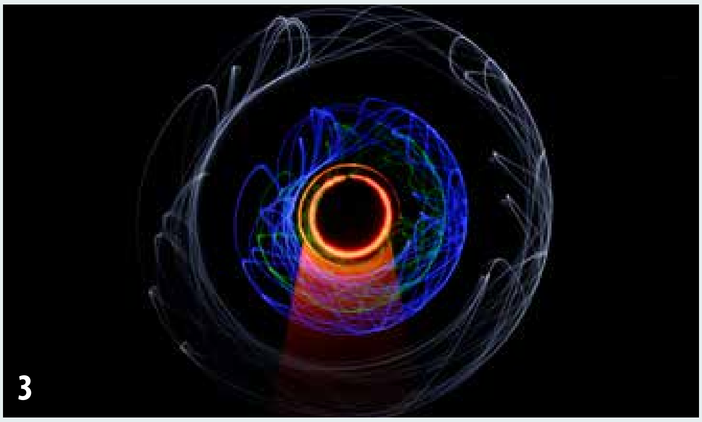
The Head of Department's prize went to Alex Kendall, for a video which demonstrates how a robot tourist would view Cambridge landmarks. Kendall's system is able to take video or images from a smartphone and reconstruct what it saw in 3D, which can then be used so that a robot can learn both its position and orientation from an image.

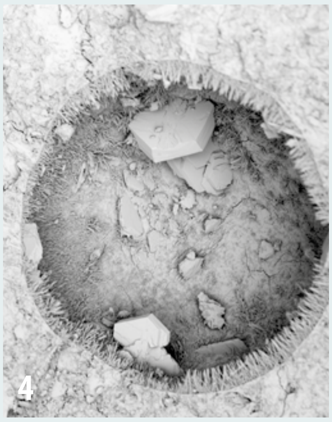
The panel of judges included Kenneth Png from ZEISS, and the Department of Engineering's Professor Roberto Cipolla, Dr Allan McRobie, Head of Department Professor David Cardwell, and Director of Research Philip Guildford. Philip said that the judges were once again impressed by the quality of the images they received.

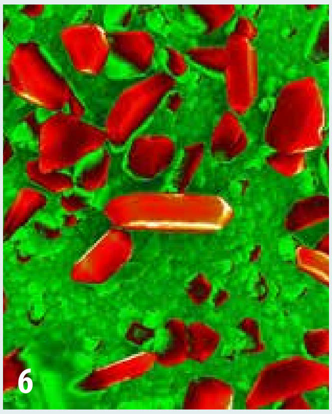
"I love the way in which the essence of engineering can be captured in a single beautiful image – these intriguing works of art convey wonderful stories of determined engineers battling to crack real world problems and finding the most elegant answers," he said.

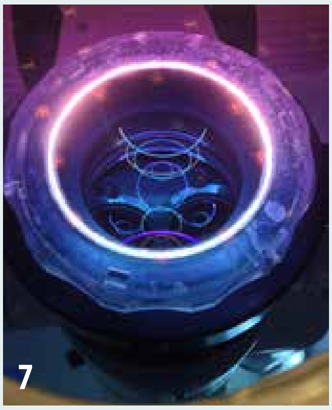


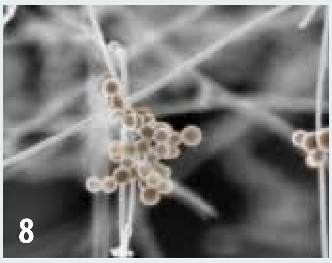


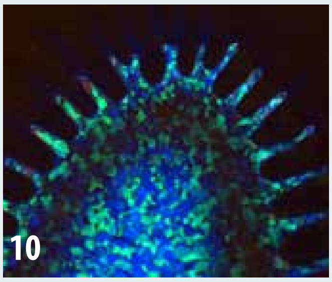


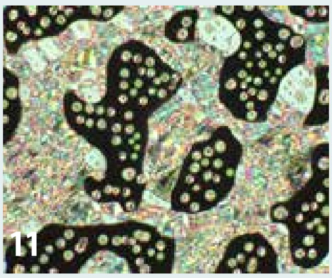












1: Second prize. Andrew Payne, *Titanium comet diaspora.*

2: Third prize. Dilek Ozgit and Andrea De Luca, *Vertically aligned multi walled carbon nanotubes.*

3: Arthur Tombs and Quang Ha, *Double Pendulum 7.*

4: Antonios Kanellopoulos, *Cement paste cavity.*

5: SEM prize. Kenichi Nakanishi, *Under the Covers.*

6: D T L Galhena, *The beauty of mistakes.*

7: Calum Williams, *The rings of optics.*

8: Christian Hoecker, *Carbon Nanotube Web.*

9: Tom Turmezei, *Inside the artist's mannequin.*

10: Rachel Garsed, *Blue phase anemone.*

11: Jennifer Jones, *Liquid gems.*

12: Simon Schofield, *Winter Stability Testing of a Solar Car.*

13: Dilek Ozgit, *Nanomaterial Enhanced Rechargeable Zinc-Silver Oxide Batteries.*

See more images and video entries on the Department's Flickr and Youtube pages:
www.eng.cam.ac.uk/Flickr
www.eng.cam.ac.uk/YouTube


Credit: Metail

Metail's 'MeModel' shopping revolution

In spite of the spiralling increase in online clothing sales, the huge number of returned items poses an important challenge to the retail industry: how to reduce the volume of returned purchases without imposing punitive conditions which may deter customers from buying.

Academics from the Department of Engineering's Computer Vision Group joined forces with Cambridge alumni at London-based technology company Metail to provide the perfect solution – give customers the tools to create 3D avatars (called MeModels) of themselves and so engage in the ultimate 'try before you buy' experience.

Professor Roberto Cipolla, Professor of Information at the Department of Engineering, has for some years led research in the Computer Vision Group with the aim of reconstructing 3D models from 2D photographs. One of Professor Cipolla's research team was Duncan Robertson, who left the Department to co-found Metail with another Cambridge alumnus, Tom Adeyoola. Duncan had worked closely with Professor Cipolla on earlier research and, jointly, they had commercialised their findings in their own Cambridge spin-out company, Redimension. Their collaboration with technology firm, Metail, was a natural progression.

Metail's focus was on the online fashion retailing industry. Tom had been inspired with the idea some years previously whilst on holiday in Vietnam. He had seen that Westerners were taking advantage of the relatively inexpensive custom-tailored clothing available there and hit upon the idea of a virtual changing room to allow customers to identify a better fit than the usual 'off the rack' garments available back at home. Back in the UK, he identified that a large number of orders being placed online were not being converted into actual sales because of the volume of unwanted, returned items. Metail's vision was to provide the industry with the technology to allow customers to easily produce a 3D image of themselves, with their own exact measurements, height, colouring and even hairstyle. They contacted the Department of Engineering for help and the quest began.

Professor Cipolla, commissioned and supported by Metail, then refined his research into producing accurate human 3D images from customer photographs and a set of body measurements. He soon realised that some simple reference geometry would be necessary in order to produce precise results, as using just a photograph with no reference threw up too many variables. Customers were asked to provide a photograph of themselves standing within a doorway, so that the door frame provided a point of reference. Using an existing database of two thousand 3D models of real human bodies as a training database, and using research which had previously resulted in the production of *Photobuilder*, the team eventually devised a method for finding the most likely body shape for each customer.

Tests showed the results to be between 94-96% accurate; an astonishing accomplishment and one that had the potential to revolutionise the online retail sector.

And so the virtual fitting room was born.

Metail's first client was retail giant Tesco, which launched the technology on its Facebook page in 2012, swiftly followed by women's fashion retailer Warehouse and a number of other companies both in and outside the UK. Tom Adeyoola said:

> The inspiration behind this technology is about solving one of the biggest problems with online shopping – clothing shape and fit.
>
> Tom Adeyoola

"The inspiration behind this technology is about solving one of the biggest problems with online shopping – clothing shape and fit. Tesco was looking to create a more personalised shopping experience and with such an infinite choice now on the Internet, consumers are looking for a more tailored and relevant offer."

Since February 2012, over 750,000 people have created their own 3D body models, called MeModels, using Metail. With 60 employees, US$20m investment and clients already in Germany, Asia and South America, Adeyoola is keen to conquer the US market next. If that happens, it will truly be a retail success story of amazing proportions with diminished returns.


Roberto Cipolla

www.eng.cam.ac.uk/profiles/rc10001
www.eng.cam.ac.uk/news/digital-pygmalion-project-photographs-3d-computer-model

Dyson Centre celebrates launch with open day for students

Credit: Quang Ha

The Dyson Centre for Engineering Design celebrated its opening with a day of demonstrations, experiments and other activities.

Cambridge engineering students were invited to tour the Centre and engage in several hands-on projects including a competition to build an automatic musical instrument from salvaged parts and a challenge to construct the strongest bridge using only cardboard.

The recently completed facility, built with a £2.65 million grant from the James Dyson Foundation and matched funding from the Higher Education Funding Council for England, is a new space for engineering students to work on individual projects. "It's a facility aimed to encourage students to do more design, creation and innovation work," said Dr Richard Roebuck, Senior Design Engineer and Manager of the Dyson Centre. "They'll come in and try to realise their ideas … try to put into practice some of the theoretical ideas they've heard in their lectures."

The Dyson Centre is equipped with tools for prototyping and making – from traditional hand- and machine-tools to modern computer-controlled machinery, 3D printers and laser cutters. It includes modern workspaces where students can develop their creativity and enthusiasm for engineering. The Engineering Library interior was also rebuilt and a glass link bridge connects the learning environments of the Library to the Dyson Centre.

The Centre is also home to several student-led teams including Cambridge University Eco Racing, Cambridge University Spaceflight, Full Blue Racing, Cambridge Autonomous Underwater Vehicle team and Project Voxel.

↑ Dyson Centre for Engineering Design

Richard Roebuck

www.eng.cam.ac.uk/profiles/rlr20
www.dysoncentre.eng.cam.ac.uk

Credit: © Windfall Films

Tackling Hitler's supergun

Dr Hugh Hunt, Reader in Engineering Dynamics and Vibration, took viewers on a journey to discover how Hitler's V-3 supergun worked and how Allied forces raced to destroy it.

By the spring of 1943, for the first time since the beginning of World War II, Hitler was on the back foot. As Allied bombs rained down on German cities, the Führer was determined to hit back. He drew up plans for the biggest gun the world has ever seen: the V-3 supergun. From its bunker buried deep in a French hillside, this monstrous 25-barrelled cannon was designed to reduce London to rubble and turn the course of the war back in Hitler's favour.

In a race to knock out the supergun, the Allies dreamt up their own miracle weapons. The Americans devised one of the world's first ever drones: a remote-controlled heavy bomber packed with explosives levelled at the gun's stronghold. The British drafted in Barnes Wallis, the genius behind the bouncing bomb. With his characteristic flair for lateral thinking, he came up with a weapon that would trigger an earthquake.

Exactly how Hitler built his supergun has remained a mystery, and the story of the Allies' mission to destroy it has never been told. Now, in a series of explosive experiments, Dr Hugh Hunt will set out to discover how the gun worked. With only a handful of grainy photographs to guide him, Hugh will build his own supergun to see if the weapon really could have brought London to its knees. He recreates Barnes Wallis's earth-shattering tests into bunker-busting technology. Finally Hunt will investigate the series of blunders that plagued the American drone strike, carrying out his own accident investigation into the flawed mission, which sealed the fate of a young man born to be president of the United States: Joe Kennedy Junior.

"I hadn't before heard of Hitler's V-3 supergun," Dr Hunt said. "It was an incredible journey. The technical complexity of the gun, and the sheer scale of it, were amazing."

Added Hugh, "I also would like to acknowledge the work of Director Ian Duncan, Producer Catherine Watling and Editor Paul Shepard from Windfall Films for making this all happen. They have done a fantastic job."

Building Hitler's Supergun: The Plot To Destroy London can be seen on Channel 4.

> I hadn't before heard of Hitler's V-3 supergun … it was an incredible journey.
>
> Hugh Hunt

www.eng.cam.ac.uk/profiles/hemh1
www.channel4.com/programmes/building-hitlers-supergun

New vibration energy harvester powers up on Forth Road Bridge

An energy harvester developed by the Cambridge Centre for Smart Infrastructure and Construction (CSIC) has been tested on the Forth Road Bridge in Scotland where, powered only by traffic and wind-induced bridge vibrations, it was demonstrated successfully powering a wireless mote which transmitted data to a receiver mote.

Credit: Philip Keenan

↑ Forth Road Bridge

Designed by CSIC's Dr Yu Jia, Dr Ashwin Seshia and the Sensors and Data Collection team, the patented low-cost, wireless, battery-free energy-harvesting device was trialled at the live site in April 2015 where it was deployed for part of a day at a number of locations under the deck of the Forth Road Bridge.

The vibration-powered wireless monitoring technology has the potential to enable maintenance-free, autonomous measurement of the behaviour of key structural elements of infrastructure, even in the most difficult-to-reach areas, giving the owner a far greater understanding of the actual capacity and level of safety of an asset.

The results of the Forth Road Bridge trial, which demonstrated that the technology works in live conditions, were presented at the world's premier academic conference on micro and nanotechnology for power and energy applications, PowerMEMS 2015, in Cambridge (MA, USA), at the close of last year.

"The paper was well received at the conference and was one of only a few academic contributions that has demonstrated the operation of the technology in a real environment," said Yu.

"Our macro-vibration energy harvesting (VEH) prototype has demonstrated the potential to generate substantially more power than devices based on more conventional approaches to vibration energy harvesting and could provide a convenient, self-sustaining on-board power solution to complement emerging wireless sensor technologies – the smarter power backbone to the ever-growing wireless infrastructure."

The conventional resonant-approaches to scavenge kinetic energy are typically confined to narrow and single-band frequencies. CSIC's vibration energy harvesting device combines both direct resonance and parametric resonance in order to enhance the power responsiveness towards more efficient harnessing of real-world ambient vibration.

In the field-site, the packaged electromagnetic harvester designed to operate in both of these resonant regimes, with an operational volume of ~126 cm^3, was capable of recovering in excess of 1 mW average raw AC power from the traffic and wind-induced vibrations in the lateral bracing structures underneath the bridge deck. The harvester was integrated off-board with a power conditioning circuit and a wireless mote. Duty-cycled wireless transmissions from the vibration-powered mote were successfully sustained by the recovered ambient energy.

"This limited duration field test provides the initial validation for realising vibration-powered wireless structural health monitoring systems in real world infrastructure, where the vibration profile is both broadband and intermittent," said Yu.

"We now plan to work on enhancing the robustness of the harvester prototype, improving the efficiency of the power conditioning circuitry, further minimising the power requirement of the WSN mote and incorporating sensor systems onto the vibration powered mote in order to realise long term deployment trials at field-sites in the near future."

A spin-out company, 8Power, is being formed to commercialise the technology. Robert Trezona, from IP Group plc, a venture capital organisation for British technology companies, said: "The new vibration harvesting energy technology developed by CSIC is a world-class innovation with several large potential markets."

A paper detailing CSIC's macro-VEH prototype and field trial, titled "A vibration powered wireless mote on the Forth Road Bridge," has been published in the *Journal of Physics: Conference Series*.

Ashwin Seshia

www.eng.cam.ac.uk/profiles/aas41
www-smartinfrastructure.eng.cam.ac.uk

Alumna Ruth Buscombe joins Haas F1 Team

Alumna Ruth Buscombe has left her role within the race strategy team at Ferrari to join the Haas F1 Team.

As Chief Strategist Ruth will attend all races with the team and take overall responsibility for the development of the team's strategy on track over a race weekend.

Whilst the Scuderia were sorry to see Ruth leave back in November 2015, they felt the move to the Haas F1 team would be preferable to a move to another competitor.

Ruth has returned from Maranello to the UK and is based at the Banbury facility forming part of the 110-strong team supported by a number of contractors across each of the Haas F1 team locations. Ruth Buscombe is the only permanent member of the Haas F1 team to have moved from Scuderia Ferrari.

Ruth joined Ferrari as a MEng graduate from the Department of Engineering having studied Aerospace and Aerothermal Engineering. Her Master's thesis, which was conducted in conjunction with the FIA and supervised by Tony Purnell (Former Jaguar and Red Bull Team Principal), was on the effect of the Drag Reduction System, an innovation introduced in 2011 in an effort to improve the spectacle of Formula One by increasing overtaking.

Outside of work Ruth has become involved with Dare To Be Different, a non-profit organisation set up by the British Motor Sports Association and former F1 test driver Susie Wolff. The initiative is aimed at advertising careers in motorsport to women. Ruth has an impressive depth and breadth of knowledge that she's keen to impart to the next generation at the forthcoming Dare To Be Different events.

For members of the Dare To Be Different Community, Ruth is also going to be heading online to speak to her peers, offer advice and share stories that will help foster new relationships and present new opportunities.

Ruth said: "It's a privilege to be an Ambassador for Dare To Be Different. It's so important that we fight the archaic stereotype that women and motor sport 'don't go together' to prevent misinformation and dogma prescribing a subset of career choices for girls. I'm proud to be a part of an initiative that will showcase the fantastic opportunities available within Motorsport; where what counts is what you can do – not what gender you are."

Susie Wolff said: "To have someone like Ruth as an Ambassador for Dare To Be Different is brilliant – she's absolutely at the top level of her profession, and an inspiration to women who want to forge a career in engineering and race strategy. We really want to shine the spotlight on women like Ruth who have made such an incredible success in motor sport, and as time goes on we will be bringing more and more amazing women to the forefront."

> It's so important that we fight the archaic stereotype that women and motor sport 'don't go together', I'm proud to be a part of an initiative that will showcase the fantastic opportunities available within Motorsport; where what counts is what you can do – not what gender you are.
>
> Ruth Buscombe

www.daretobedifferent.org

Alumnus helps bring Dyson Centre to life

The recently opened Dyson Centre for Engineering Design has been supported by a £300,000 grant from Denis Burrell CBE via the Burrell Family Charitable Trust.

Burrell studied at Clare College and graduated from the School of Technology with a first class honours degree in Mechanical Sciences. His first job was as a stress engineer at family business Martin-Baker Aircraft Company. At the time it was developing ejection seats for military aircraft, for which it is now world-famous. He then gained experience in other areas of the business and was subsequently appointed Chair and Managing Director in 1984 on the death of the founder of the company Sir James Martin.

In 1981, Burrell was elected Fellow of the Royal Aeronautical Society and became Honorary Fellow in 1999. He is a Chartered Engineer, holds honorary doctorates from Brunel University and the University of Buckingham and was a member of the Court of Cranfield University. In 1982 he was appointed CBE for Services to Export.

He is a Deputy Lieutenant for Buckinghamshire and was High Sheriff of Buckinghamshire from 1997–1998.

The Department of Engineering's Dyson Centre for Engineering Design was established with a £2 million donation from the Dyson Foundation and matched funding from the Higher Education Funding Council for England. The Centre provides modern rapid prototyping hardware; a range of hands-on and interactive aids; machine tools; and interactive apparatus to give students knowledge and confidence to invent and innovate their own designs and creations.

Professor David Cardwell, Head of the Department of Engineering, said: "We are incredibly grateful for Denis's generous support of the Department and its students, which will enable them to turn their innovative ideas into reality."

The facility offers a place for 21st century engineers to come together to think, exchange ideas, design, experiment and build. Its vision is to provide a space in which engineering students can lead projects; develop creative and innovative engineered responses; and in which school groups can be hosted and engaged.

Credit: Quang Ha

↑ Dyson Centre for Engineering Design

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We are incredibly grateful for Denis's generous support of the Department and its students, which will enable them to turn their innovative ideas into reality.

David Cardwell

www.dysoncentre.eng.cam.ac.uk

Alumna Helen Morton's bequest to support Women in Engineering within the Department

Helen Morton (New Hall, 1971) has made a generous bequest to the Department leaving a substantial proportion of her estate in order to support women engineers within the Department.

As a former Bursar of an Oxford College Helen knows that legacies are an important source of funding for educational institutions and wanted to do something to support the Department. Helen read Engineering at Cambridge at a time when there were so few female engineers that she wasn't able to have supervisions in her own college New Hall and so had to attend teaching in other colleges such as St John's and Sidney Sussex.

Helen trained as a civil engineer and worked on the Thames Barrier. She then moved to BP to work on offshore oil platform projects in the North Sea, and refineries in Europe and Australia and took up various corporate roles, including Company Secretary for BP Oil. While at BP, she completed a part time MScBA with Boston University. She left the oil industry in 1992 to work in the charity sector, including VSO, Marie Stopes International and five years as Finance & Administration Director at Trinity Hospice, London. In 2000, she moved to Oxford to become the Treasurer (Finance & Estates Bursar) at Somerville College, Oxford. She took early retirement at the end of 2012 to give her more time to concentrate on her musical and outside interests. These include being a Director of Experience Oxfordshire and Experience Oxfordshire Charitable Trust, the Chair of Trustees of the Oxford Radcliffe Hospitals Charitable Funds, a Governor of Oxford High School and of Pipers Corner School and a Trustee of the University Women's Club.

The Department is deeply grateful for philanthropic funding for specific projects as well as funding that allows Engineering students and staff the freedom to discover. The recently-launched campaign for the University and Colleges of Cambridge, will raise £2 billion to help us shape all our futures.

↑ Helen Morton (third from right) alongside colleagues at Magnus oil platform, 1985

More news of fundraising plans and successes will be forthcoming. Please do not hesitate to contact the Department if you want to get involved.

www.philanthropy.cam.ac.uk

INTERVIEW

Matthew Juniper, Professor of Thermofluid Dynamics

Professor Matthew Juniper read Natural Sciences and Engineering as an undergraduate at St John's College from 1992 to 1997. In 1994 his leg was amputated after being badly broken during a rugby match. He started sprinting competitively in 1995 and competed in the Atlanta Paralympics in 1996, coming 4th in the 200m. He won silver in the 4x400m relay at the Birmingham World Championships in 1998. He is now Professor of Thermofluid Dynamics and a fellow of Trinity College.

In this excerpted interview with the Cambridge Blue Bird, he speaks about his time in the Paralympics and how this influences his work.

Tell us a bit about your general sporting background.

I was a fast runner at school, mainly 400m and 800m, but decided to play rugby at university because it is more fun. Being fast and good at tackling, but not particularly skilful with a ball, I played either wing or full-back. I broke my leg at the end of a gritty wet game against Caius in a bad collision that was entirely my fault.

They decided to amputate my leg after six weeks of increasingly unsuccessful operations and, by that stage, it came as a relief. While in bed I had had plenty of time to consider a future with a limp leg – in a weak moment I had even considered taking up golf – but the amputation opened up more interesting possibilities.

Credit: Mark Zaleski Photography

↑ Matthew Juniper competing in the long jump in Atlanta, 1996

Two years previously, in 1992, I had seen snippets of the Barcelona Paralympics and remembered the single amputee Denis Oehler complaining that the double amputee Tony Volpentest had won gold only by making his legs 3 inches longer than they should have been. (Pistorius and Oliviera had exactly the same argument after Pistorius' defeat in the 200m at London 2012.) The fact that an amputee could run 100m in under 12 seconds intrigued me in 1992. It became more relevant to me in 1994 and was a huge source of comfort as they wheeled me down to theatre. So I think seeing the 1992 Paralympics was instrumental in my decision to take up running with an artificial leg.

How did it feel to compete in the Atlanta Games in 1996?

Perhaps I can best convey the feeling by describing the process leading up to a race. You are told to assemble with the other athletes at the warm-up track several hours before the race, which is when the psychological battle begins – I heard one competitor, with Oscars-worthy concern, ask another why he was looking so sluggish. After an hour or so of warm-up, the eight in each race are bussed together into a small dimly-lit room below the stadium to stare at each other until the race is called. Then the marshals lead you through a tunnel towards a small rectangle of light that suddenly expands into a blinding arena containing 80,000 cheering people. On the big screen you see your other self strip down to shorts and vest and hand all his belongings to a marshal. You look down the lane, to a finish line so close you could touch, crouch on the blocks, and find yourself three steps into the race before you realise the gun has gone off. Everybody has the same feeling about a big race: at the start, you would rather be anywhere else in the world. At the end, your only desire is to experience it again.

Do you take much interest in how prosthetics are designed and the engineering that goes into them?

Absolutely. I think we may soon see amputee athletes regularly out-performing their able-bodied counterparts in some events. The key factors are that, firstly, an artificial leg can be tuned to a specific natural frequency and, secondly, it can flex more, allowing more contact time with the ground.

This debate, about whether an artificial leg is better than a real leg, is heated and sometimes acrimonious. Having given my tuppence worth, I'll run for the hills and see what happens in Rio this year.

> "I think we may soon see amputee athletes regularly out-performing their able-bodied counterparts in some events."
>
> Matthew Juniper

Matthew Juniper

www.eng.cam.ac.uk/profiles/mpj1001
www.bluebirdnews.co.uk

Empathy and engineering

Can our brain type explain the gender gap in STEM subjects and careers?

It's no secret that far fewer females enter into STEM (Science, Technology, Engineering and Maths) professions and fields such as engineering struggle to recruit women.

There have been a number of ineffective and stereotypical attempts to encourage girls into engineering which have failed to have a positive impact. Katie Klavenes, Research Assistant & Resource Developer at the Department's Engineering Design Centre (EDC), argues that it is a brain type rather than a gender issue that encourages males into STEM fields.

Klavenes conducted a small scale research study in order to better understand the causes of gender disparity in STEM by investigating year 9 pupils' (13-14 years) relationship between their brain type, gender and their enjoyment of subjects and tasks.

Klavenes found that there are significant differences between the empathising and systemising abilities of the year 9 boys and girls that took part in the survey. This finding is in congruence with the findings of Baron-Cohen that on average more males than females are Systemisers, and that on average more females than males are Empathisers. Klavenes' findings clarify that school-aged pupils show stark gender differences in terms of their systemising ability and this may be an indicator as to why boys and girls choose to pursue alternative school subjects, degrees and ultimately career choices.

Interview data collected by Klavenes in her study suggests that there is a relationship between pupils' preferences, motivations, and their gender and/or brain type. Broadly speaking there were no significant gender differences in the subject choices preferred by boys and girls, nor by empathising or systemising pupils. A key element of significance, however, was pupils' reasoning behind their preferences of activities in and out of school. Systemising (male and female) and Empathising and Balanced (where empathising and systemising abilities are equally strong) pupils (male and female) tended to speak of their attitudes and opinions towards subjects and tasks in conflicting ways.

Throughout the interview discussions with pupils it became apparent to Klavenes that there is a divide in brain type preferences between: systematic tasks, such as finding the answer to an equation; and the exploration of tasks that involved people and the world that are more akin to empathy. Perhaps surprisingly, across all brain types, pupils expressed their enjoyment of tasks that were in a real-world context; although, this was a particularly significant motivation for Empathising pupils (male and female). Klavenes argues, in light of her findings, that context is important to all pupils, but in particular empathising pupils of both genders.

It is Klavenes' feeling that STEM subjects must do more to connect with the Empathisers in giving pupils this real-world context in order that more Empathisers, and, therefore, more females, go on to study and ultimately pursue careers in these fields. Klavenes suggests that empathy should be explicit within STEM subjects and, that gender diversity in fields such as engineering would be beneficial to the industry. Gender diversity would bring in a greater number of professionals who are pre-disposed towards empathy, and who genuinely see the world from a different perspective. Klavenes believes this would go some way to increasing the numbers required in the field and improve the way in which engineers work. It is critical to the engagement of Empathisers, who are in the majority girls, that they regard their learning as meaningful.

Following completion of her MPhil, Klavenes has begun working on a joint initiative named Designing Our Tomorrow (DOT) between the Faculty of Education and the Engineering Design Centre within the Department of Engineering. DOT sees that there is a hole in the heart of STEM which is the societal need. DOT intends to fill this gap by bringing authentic engineering practice. Klavenes and DOT seek to develop schemes of work for Design and Technology (D&T) that promote creativity, empathy and self-efficacy whilst offering a real-world context by authentic problems presented by industry partners.

Katie Klavenes

www.eng.cam.ac.uk/profiles/khk33
www-edc.eng.cam.ac.uk

Professor Kenneth Johnson 1925–2015

Professor Kenneth Johnson FRS, FEng, Professor Emeritus in the Department of Engineering and leading figure in contact mechanics, has died, aged 90.

Professor Johnson earned his BSc and MSc degrees at the University of Manchester, and then spent five years in industry at Rotol working on vibration and propeller research. While Assistant Lecturer at the Manchester College of Technology, he earned his PhD on 'surface interactions between elastically loaded bodies under tangential forces.'

His time at the University of Cambridge began in 1954 and he was appointed Professor of Engineering in 1977. In his time at Cambridge, Professor Johnson studied contact mechanics, examining concepts such as rolling contact with creep and spin. As the Institution of Mechanical Engineers writes, his work was characterised by elegant experiments, skilful analyses and insightful explanations of observed phenomena.

Professor Johnson was elected as Fellow of the Royal Society in 1982. Regarded for his expertise in the field, he authored *Contact Mechanics* in 1985 and was awarded the Tribology Gold medal that same year. He also received the ASME Mayo D Hersey award in 1991, the Royal Society Medal in 2003, and the Timoshenko Medal, one of the highest honours in the field of applied mechanics, in 2006.

Professor Kenneth Langstreth Johnson, born 19 March 1925, died 21 September 2015.

Lessons in entrepreneurial design

Several alumni have found success through the Innovation Design Engineering (IDE) double masters programme, a jointly run venture of the Royal College of Art (RCA) and Imperial College London (ICL).

"We explore and help postgraduate students develop their skills in a wide range of functional attributes from technical aspects, to aesthetic, economic, social, psychological, emergent and latent," explained Peter Childs, head of the Dyson School of Design Engineering at ICL and a joint course director in the Innovation Design Engineering programme.

"The result," said Dr Dominic Southgate, senior teaching fellow at the Dyson School of Design Engineering, "is students who excel at exploring novel applications for emerging technologies but are able to really understand user needs when creating new products and systems."

Following are some insights from alumni of the Department of Engineering about their experiences in the RCA-Imperial double masters programme.

"Though I had little idea of what sort of engineer I might want to be, Engineering at the University of Cambridge allowed me to start general and become specific … The IDE course opened my eyes to the existence of design as an industrial activity, incorporating creative inspiration, real-life experience, and analytical method."

Ollie Price (1992), Founder of Opid

The University of Cambridge's world class academic reputation made it a clear choice for my undergraduate studies … design cannot exist without technical grounding and resolution, and it was through IDE that the two worlds were brought together. The nature of the programme granted me two years of intellectual freedom to pursue any interesting problem that caught my attention.

Wai-chuen Cheung (2013), Founder of Metadrift

Where Cambridge engineering was more analytical, in the IDE focus was more user-centred and required an in-depth understanding of how products are actually manufactured. It gave me the skills and confidence to combine product design and engineering mind-sets. My time at Cambridge and in the IDE were both immensely enjoyable.

Robin Sayer (1990), Head of Mechanical Engineering, NHS Greater Glasgow and Clyde

"Design has been and will always be a great skill and body of knowledge that complements the practice of engineering. The IDE programme was a clear beacon of the fusion of the two disciplines. Eventually the course proved instrumental to my career, introducing me to the idea of developing my own design and engineering practice."

Aran Dasan (2010), Teaching Fellow at Imperial College London

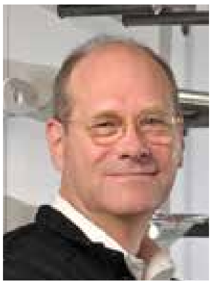
"At Cambridge, I first learnt engineering – how things work, how to work hard and succeed at seemingly impossible amounts of work … The IDE course liberated me as an engineer. It helped bridge the gap between scientist and inventor."

Michael Korn (2004), Director at KwickScreen

Credit: Kwikscreen

↑ KwickScreen is a flexible, attractive and hygienic barrier for hospital environments.

Honours, awards and prizes



William Baker has been awarded an Honorary Professorship in Structural Engineering Design. The University of Cambridge has bestowed the honour on Bill Baker in recognition of his global reputation and outstanding contribution to his field.

Baker designed the buttressed core system of the world's tallest building, the Burj Khalifa in Dubai, as well as working on a number of other "supertall" buildings.

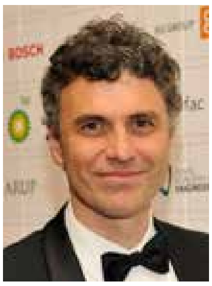
University of Cambridge and the LEGO Foundation have launched a new research centre and professorship. The Centre for Research on Play in Education, Development and Learning (PEDAL) has been established with a £4 million grant from the LEGO Foundation which will also fund the leadership role of the LEGO Professorship of Play in Education, Development and Learning. LEGO bricks have been used by students in the Department of Engineering for many years allowing for a large degree of play, experimentation and freedom in teaching and research programmes.

Doctoral researcher in the Centre for Sustainable Development **Kirsten Van Fossen** has won World Rowing's 2015 Parmigiani Spirit Award. The award is granted to university rowers who have 'demonstrated the core values of the sport of rowing – commitment, dedication, determination, endurance, fairness, focus, inclusiveness, life balance, respect for nature, self-discipline and teamwork'.

Dame Ann Dowling, Professor of Mechanical Engineering and former Head of Department, has been appointed to the Order of Merit by HM The Queen. The Order of Merit is given to those who have rendered exceptionally meritorious services towards the advancement of the arts, learning, literature and science.

Over the past year, Professor Dowling has also received honorary degrees from Oxford, Leeds, Queen's University Belfast, London South Bank University and Heriot-Watt.

Professor Robert Mair CBE FREng FRS has been appointed to the House of Lords as an independent crossbencher. The Sir Kirby Laing Professor of Civil Engineering and a leading expert on infrastructure and construction, Professor Mair is a Fellow of both the Royal Academy of Engineering and the Royal Society, Head of Civil and Environmental Engineering at Cambridge University, and was Master of Jesus College from 2001 to 2011.



Professor Florin Udrea has been elected Fellow of the Royal Academy of Engineering. Leading the High Voltage Microelectronics group as well as founding two of the University's most successful start-ups: Cambridge Semiconductor Ltd and Cambridge CMOS Sensors Ltd, Professor Udrea's research is in the areas of electronic devices for electrical power/energy control and gas sensing.

Junior Research Fellow **Jack Alexander-Webber** has won an Elsevier Early Career Researcher Award. Jack works in Dr Stephan Hofmann's group within the Electrical Engineering Division, studying new nanostructured materials.

Abir Al-Tabbaa, Professor of Civil and Environmental Engineering, spoke at the World Economic Forum Annual Meeting on self-healing construction materials with a focus on concrete and its vast implications for construction and other sectors. Also discussed was addressing the gender imbalance at the top and at the bottom at school level in STEM subjects.

The Fellows of St Catharine's have elected **Professor Sir Mark Welland**, Professor of Nanotechnology and Head of Electrical Engineering, as the next Master of the College. Sir Mark will take up office in September 2016, succeeding Professor Dame Jean Thomas, who has been Master of St Catharine's since 2007.

Bill Gates has included *Sustainable Materials – with both eyes open* by **Professor Julian Allwood**, Professor of Engineering and the Environment, and **Dr Jonathan Cullen**, Lecturer in Energy, Transport and Urban Infrastructure, in his list of the six best books of 2015.

A 1967 sculpture at the Department of Engineering is among 41 post-war public sculptures listed by the Department for Culture, Media and Sport on the advice of Historic England. Kenneth Martin's *Construction in Aluminium* resides on Trumpington Street in Cambridge and was inspired by the intersection of physics and music.

Heads up

Cambridge holographic technology adopted by Jaguar Land Rover

A 'head-up' display for passenger vehicles, which was conceptualised in the Department of Engineering more than a decade ago, has been incorporated into Jaguar Land Rover vehicles.

Credit: Jaguar Land Rover

↑ **Head-Up Display (HUD) projects key driving information onto a small area of the windscreen**

Cars can now park for us, help us from skidding out of control, or even prevent us from colliding with other cars. Head-up displays (HUD) are one of the many features which have been incorporated into cars in recent years. Alongside the development of more sophisticated in-car technology, various companies around the world, most notably Google, are developing autonomous cars.

"We're moving towards a fully immersive driver experience in cars, and we think holographic technology could be a big part of that, by providing important information, or even by encouraging good driver behaviour," said one of the technology's developers, Professor Daping Chu Chair of the Centre for Advanced Photonics and Electronics (CAPE).

The holographic HUD technology originated with Emeritus Professor Bill Crossland in 2001, and was licensed to and developed by CAPE partner company Alps Electric, and then by Two Trees Photonics Ltd at Milton Keynes, in collaboration with researchers at CAPE. Products were designed by Two Trees Photonics and Alps, and manufactured by Alps for Jaguar Land Rover. The HUD became an available option on their vehicles in September 2014.

The HUD technology developed at Cambridge is the first to use laser holographic techniques, which provide better colour, brightness and contrast than other systems, but in a smaller, lighter package. It provides key information to the driver without them having to take their eyes away from the road.

But according to Chu, the technology's potential has yet to be fully realised, and its real advantage is what it could be used for in future models. "What we really want to see is a fully 3D display which can provide much more information to the driver in a non-intrusive way – this is still a first generation piece of technology," he said.

Most of the HUDs in passenger cars display similar information as can be seen on the dashboard – speedometer and tachometer, as well as navigation information.

Some models also display night vision information. The commercially-available Cambridge HUD projects information which is relevant to the driver onto the windscreen, in full colour and in two dimensions. But according to Chu, this type of technology is just getting started.

"There are three main types of information that we could integrate into future holographic head-up displays in the future," he said. "The first is the type of information that's on today's displays, but potentially we could add other information in a non-intrusive way: for example, if the driver passes a petrol station, perhaps the price of petrol at that station could flash up in the corner – the trick is how to display the most useful information in a way that doesn't distract the driver.

"The car will evolve," said Chu. "I'm sure in 50 years' time, everything in cars will be controlled by computers, but it's being developed in different directions. The sorts of questions we're interested in answering are around the idea of integrating critical and non-critical systems in a vehicle. When these systems are integrated, who ultimately makes the decision – the car or the driver? And in the case of disagreement, who wins?"

Lee Skrypchuk, Human Machine Interface Technical Specialist at Jaguar Land Rover, said: "The development of a laser holographic HUD presented a number of technical challenges but also a number of benefits including small package size, high optical efficiency, wide colour gamut and cross platform compatibility. Incorporating a laser holographic light engine was a true world first application of technology for Jaguar Land Rover and I'm delighted that the technology has worked so well in our vehicles."

Daping Chu

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