Medical Physics and Biomedical Engineering
Annual Newsletter 2018
Transforming technology into healthcare
Welcome to the 2018 edition of the annual newsletter of the UCL Department of Medical Physics and Biomedical Engineering.

It has been a busy year for us. Our research has been hitting the headlines, we’ve embarked on exciting new collaborations and delivered a number of innovative outreach activities aimed at inspiring the next generation of medical physicists and biomedical engineers.

We are a friendly, welcoming and dynamic department, justly proud of our excellent research. Whether improving the life chances of neonates in Gambia, developing apps to diagnose anaemia and jaundice in Ghana, or improving outcomes for people affected by multiple sclerosis or liver cancer or undergoing radiotherapy, our researchers are working towards saving lives and improving health outcomes across the world.

Our students learn from the best, benefiting from a truly connected curriculum, acquiring the team working and problem solving skills which will prove so invaluable in their future careers. A degree in Medical Physics or Biomedical Engineering opens many doors, as evidenced by the alumni we profile on pages 22–23, who are pursuing careers in sectors as diverse as research, management consultancy and software engineering.

We hope you enjoy our newsletter.

If you have any questions or comments, we would be delighted to hear from you, via medphys.newsletter@ucl.ac.uk

Jem Hebden
Head of Department

Contact Us

Department of Medical Physics and Biomedical Engineering,
University College London,
Gower Street, London WC1E 6BT
Web: www.ucl.ac.uk/medphys
Tel: 020 7679 0200
Email: medphys.newsletter@ucl.ac.uk
Twitter: @UCLmedphys
Unlocking the secrets of ancient Egypt

A team led by Adam Gibson (Biomedical Optics Research Lab) has used multispectral imaging to safely decipher messages on mummies without damaging them. The research was picked up by the BBC and other major news networks including Newsweek, Sputnik International and the Daily Mail.

The papyrus which was used to cover mummies is known as ‘cartonnage’. Unlike the hieroglyphics found on the walls of tombs of the Pharaohs, which depicted how the rich and powerful wished to be seen, these scraps of papyrus were the waste paper of their day, and are highly prized by historians and Egyptologists because of the insights they provide into the day to day lives of ancient Egyptians.

The writing on the cartonnage is often obscured by paste and plaster which could previously only be accessed by cracking open the casing. Adam’s team, which included PhD student Cerys Jones and Melissa Terras and Kathryn Piquette (UCL Centre for Digital Humanities) imaged the cartonnage with different wavelengths of light, making the inks on the inscriptions visible to the naked eye.

Adam comments: ‘Because these scraps of waste papyrus were used to make prestige objects, they weren’t thrown away, and have been preserved for 2,000 years. They give us the real story of ancient Egypt, not the sanitised version the Pharaohs wanted to portray’.

Their work was partly funded by Arcadia, a charitable fund of Lisbet Rausing and Peter Baldwin, R B Toth Associates, and the SEAHa Centre for Doctoral Training.

First demonstration of all-optical ultrasound set to transform heart surgery

A revolutionary new optical ultrasound needle able to image heart tissue in real time during keyhole surgery has been developed by a team co-led by Adrien Desjardins (Photoacoustic Imaging and Optical Ultrasound Sensing) in the first demonstration of all-optical ultrasound imaging in a clinically realistic environment.

The needle’s highly sensitive optical fibre sensors were based on polymer optical microresonators for detecting ultrasound waves, developed by Edward Zhang and in a related piece of UCL research reported in Nature Photonics.

Adrien and colleagues from Queen Mary University of London trialled the optical needle in pigs, during minimally invasive keyhole heart surgery, where it provided unprecedented high-resolution images of soft tissue. They are now working towards translating the technology for clinical use in patients.

The technology has been designed to be fully compatible with MRI and other current methods, meaning it could also be used during brain or fetal surgery, or to assist in guiding epidural needles.

The work was funded by the European Research Council, The Wellcome Trust, the Engineering and Physical Sciences Research Council and the NIHR Barts Biomedical Research Centre.
**Public engagement project featured in The Engineer**

Ilias Tachtsidis and Gemma Bale (Multimodal Spectroscopy Group) were interviewed in *The Engineer* about their public engagement work, aimed at encouraging the next generation of medical physicists and biomedical engineers.

‘The invention of the X-ray machine in the 19th century marked the birth of Medical Physics and Biomedical Engineering’, explains Ilias. ‘In the 21st century, developments in Medical Physics and Biomedical Engineering continue to revolutionise modern healthcare, and yet how many people actually know what Medical Physics and Biomedical Engineering are? Our aim is to engage the public with some of our most exciting technological developments in these areas funded by The Wellcome Trust.

‘One of our main objectives in our public engagement programme is to allow people, especially young people, to experience being a biomedical engineer by interacting with our Metabolight activities’.

---

**Standing up to cancer**

Jamie McClelland’s (Centre for Medical Image Computing) work on real-time imaging of tumours using a new radiotherapy machine known as MR-Linac was featured in Cancer Research UK’s campaign video ‘Meet the Stand Up to Cancer Scientists’.

The MR-Linac has the potential to revolutionise radiotherapy treatment, particularly of tumours that move during treatment, such as lung tumours, because it can provide realtime imaging while the radiotherapy treatment is being delivered.

**Bradley Treeby wins R. Bruce Lindsay Award**

Bradley Treeby (Biomedical Ultrasound Group) has won the 2017 R Bruce Lindsay Award, presented every year to a young researcher in recognition of their contribution to theoretical or applied acoustics.

Bradley’s research sits at the interface between physical acoustics, biomedical ultrasound, numerical methods and high-performance computing and his significant contributions have earned him an outstanding reputation within the ultrasound modeling community.

---

**Prizewinning poster**

Congratulations to Lynsey Duffell (Implanted Devices Group, pictured), who won first place in the poster competition at RehabWeek2017 for her poster ‘The Effects of Transcutaneous Spinal Cord Stimulation on Corticospinal Excitability’. Lynsey’s research focuses on improving health and quality of life for people with longstanding health conditions.
Niftynet launch

The Centre for Medical Image Computing is part of a research consortium behind the launch of **NiftyNet**, the first open source deep-learning software library dedicated to medical imaging.

NiftyNet spans several research groups within UCL and is led by the Wellcome/EPSRC Centre for Interventional and Surgical Sciences. It has been set up to accelerate research in the field by creating a common infrastructure for scientists to use, and making it easier to disseminate research tools.

Improving our understanding of Multiple Sclerosis (MS) progression

The Translational Imaging Group (TIG) has developed a new image reconstruction tool which is set to enhance our understanding of disease progression markers in multiple sclerosis (MS).

The tool was developed to support a landmark longitudinal study of 132 MS patients led by the Queen Square Multiple Sclerosis Centre at the Institute of Neurology.

The study has been tracking a group of patients since the 1980s and the MRI scans from this time, held at the National Hospital for Neurology and Neurosurgery (NHNN), are some of the earliest on record. As the files are held on film and predate digital archives, modern image analysis techniques which can help clinicians to spot changes in brain structure and volume could not be applied.

The TIG team digitised 300 sets of historic films, then created a novel algorithm to create new, sharper versions of the scans. Researchers are now able to apply modern image analysis methods to the scans so as to better identify potential disease and symptom development patterns.

The process is detailed in a recently published paper, *Volumetric reconstruction from printed films: Enabling 30-year longitudinal analysis in MR neuroimaging* and the framework used is open source and available on GitHub. [https://www.ncbi.nlm.nih.gov/pubmed/29017867](https://www.ncbi.nlm.nih.gov/pubmed/29017867)

Research fellowship awards

Charlotte Hagen (pictured) has been awarded a 5-year fellowship to develop new 3D imaging techniques for tissue engineering. The research fellowships are supported through the UK government’s Investment in Research Talent initiative, and are designed to advance excellence in engineering by enabling outstanding early-career academics to concentrate on basic research in any field of engineering.
Congratulations to our high flying student prizewinners, who were presented with their awards by Head of Department Jem Hebden.

This year's prizewinners were:

- Sidney Russ Prize for the best performance by a final year student – Martin Tan.
- Joseph Rotblat Prize for best performance by an MSc student – Cornelius Bauer.
- Institute of Physics and Engineering in Medicine (IPEM) Prize for Best MSc Project – Kin Li.
- Medical Physics and Biomedical Engineering PhD Prize – Michael Brown.
- John Clifton Prize for best performance by a non-final-year graduate – Oriana Arsenov and Cyrus Tanade (joint winners).

Cornelius Bauer

I studied the MSc Medical Physics and Biomedical Engineering course to complement my undergraduate degree in physics. I wanted a course that would allow me to apply knowledge of fundamental concepts to improving modern healthcare.

I really enjoyed the comprehensive range of lectures and the interleaved structure of the MSc Project, which enabled me to acquire solid specialist knowledge as well as more advanced skills in a specific topic (Biomedical Optics in my case). The MSc project was a great opportunity to perform individual research while being supervised by cutting edge researchers.

I intend to stay in Medical Physics. I am now pursuing a Master’s in Physics in preparation for a PhD. My UCL degree has provided me with the skills I need to perform in many different specialisations, and given me the confidence to forge a career in academia (but also join the ‘free market’ in the future if I wish to!).

Ariana Arsenov

I am currently a second-year undergraduate studying for an MSci in Medical Physics. I chose this course as I wanted to get a deeper understanding of physics phenomena and explore the latest, most advanced concepts in this field with applications in medicine and healthcare.

Studying at UCL is one of the most rewarding and enjoyable experiences I have had. A science degree requires hard work and determination, but it’s well worth it. The knowledge and transferable skills you acquire are essential for any future career. The MSci in Medical Physics offers undergraduates a wide variety of high quality courses (mathematics, computing, laboratory work, different physics and medical physics modules). This is a very friendly department, and the professors and staff are very helpful and supportive. Graduates from this course will find that there are many employment opportunities available. At the moment, I am trying to discover what an academic and scientific research career entails. I am also considering a career in the medical devices industry. But, whatever path I choose, I am confident that studying medical physics at UCL is the ideal starting point.

Michael Brown

I joined the department four years ago as a PhD student in the Biomedical Ultrasound Group, working on a project aimed at developing new techniques for generating ultrasound fields focused over complex patterns such as continuous shapes. Such fields have potential applications in ultrasound particle manipulation or for stimulating brain structures. My prizewinning paper demonstrated how it is possible to exploit the potential of 3D printing. We are now able to print lenses with nearly any surface shape, and to design lenses which are cheap to manufacture and capable of focusing sound over much more complex patterns.
I have now completed my PhD and am working on a two-year project in the Photoacoustic Imaging Group to develop a new type of scanner capable of generating photoacoustic images very rapidly.

**Cyrus Tanade**

I was originally pursuing a career in Medicine, but when I shadowed a renowned neurosurgeon in Indonesia as part of my studies I developed a fascination for the symbiotic relationship between medicine and engineering.

I am studying for a MEng in Biomedical Engineering. I really enjoy the sense of community in this department. It nurtures a mindset of teamwork and collaboration which sets us apart from other institutions with a more cut throat and competitive culture. Dr. Atul Gawande, a famous surgeon who has inspired me for years, remarked that only group success can bring about change and incite the next paradigm shift in medicine. I believe our department is the ideal environment to achieve this.

My ambitions have changed during my two years at UCL. I initially never considered returning to Indonesia after completing my studies, but now I feel an intrinsic urge to do so. Indonesia unquestionably lags behind in terms of medicine and technology, and I want to help change that. I am confident that the networks I have built in my time at UCL will help me get there.

**How did first year students tackle a big, real life engineering challenge?**

*Engineering Challenge* is a 10-week team project for all first year engineering students in the Faculty.

Students are challenged to tackle real life engineering problems, and in the process learn about the technical aspects of the problem, consider who potential stakeholders might be, and develop teamwork, research and presentation skills.

This year, the first challenge for our Biomedical Engineering students was to design a lung cancer diagnostic system for rural China, where resources were low and villagers scattered in a mountainous area. Five student teams were given introductory talks about cancer imaging and the cancer crisis in China, and taken to our research labs (radiation physics, electrical impedance tomography, ultrasound imaging, and optical imaging) to see the latest medical technologies and interact with leading researchers in the field. They were then asked to prepare presentations using whatever format they liked.

The teams’ presentations, and solutions, were highly innovative. One of the teams came up with ‘Spooter’, a group of scooters going around collecting sputum samples for screening lung cancer ([https://youtu.be/tpwLRu8lehC](https://youtu.be/tpwLRu8lehC)).

But the winning idea (as judged by their peers) was a vertical CT scanner in a truck, which enabled the patient to sit vertically on a rotating chair with a fixed X-ray source and detector (demonstrated using Lego bricks) ([https://youtu.be/RPNMTD1wWBq](https://youtu.be/RPNMTD1wWBq)).
Inspiring the next generation: why public engagement matters

Clare Elwell

At school I studied Maths, Physics and Chemistry A Level and had an interest in all things medical. Everyone told me I was going to be a doctor.

But all that changed when, in the summer of 1984, aged 17, I was sponsored to attend the London International Youth Science Forum, an annual event which gathers hundreds of students from around the world to learn about science from lectures, debates and visits to various labs and institutions.

The event included a visit to the Royal Marsden Hospital, where I was introduced to Medical Physics for the first time. Straight away I realised that this was a perfect way for me to combine my love of maths and physics with my interest in medicine. I went on to take a degree in Medical Physics and have spent the last three decades working in the field.

Being exposed to Medical Physics while I was still at school had a huge impact on my choice of future career. Today, it remains a little known discipline and too often students are not fully of aware that it even exists. This is one of the reasons that I’m strongly committed to public engagement and outreach activities. But there are other reasons too.

Public engagement and outreach activities have enhanced my communication skills and had a positive impact on how I present my work to scientific audiences. It can be particularly valuable for PhD students; presenting your first talk at a scientific conference can be daunting, but if you have had the opportunity to talk about your work in simple and clear terms in a less intimidating environment it can be a great confidence builder.

There are lots of audiences to engage with and learn from. I’ve done stand up routines in pubs as part of the Science Show Off and Pint of Science events, presented in front of policy makers and funders at the House of Commons and demonstrated Doppler ultrasound to primary school children. Each of these activities has led to unexpected and stimulating questions and interactions which have given me food for thought about the work I do and the impact it can have.

It’s also a great way to build teams. Some of the activities I have contributed to have required significant team work and this has been a really valuable experience for our research group. We have developed exhibits for The Royal Society Summer Science Exhibition in both London and Glasgow, and for the On Light event at the Wellcome Collection, each of which have brought together students, postdocs and senior academics for a common purpose. Most recently one of my PhD students led an open day for participants in the BRIGHT project, which is investigating infant brain development in a rural Gambian village. This event, funded by a UCL Culture Train and Engage grant, brought together UK and Gambian researchers to devise novel ways of engaging the local (and predominantly illiterate) community with the methods, aims and ambitions of our project.

We can make a difference. Recently, I gave a case study lecture to the second year Biomedical Engineering students. Two of them approached me at the end. One had seen me speak at a Physics in Action event for sixth formers, while the other had been present at an alumni talk I had given at the London International Youth Science Forum. Both cited these events as the moment they had taken the decision to study Biomedical Engineering instead of Medicine. And both were female. Evidence, if any were needed, that public engagement and outreach can, and does, have a direct impact on recruitment.

In 2018, 34 years after I first attended the event as a 17 year old, I became Academic President of the London International Youth Science Forum. This summer, we will be celebrating its 60th Anniversary.

I will always be grateful that this event introduced me to Medical Physics and I look forward to doing my best to inspire the next generation of medical physicists and biomedical engineers.
An NIRS assessment is performed on an 18-day old baby: Keneba, The Gambia @bright_project
Public engagement case studies

The Brilliant Club Scholars Programme

The Brilliant Club is an organisation which mobilises PhD students to engage with state schools, and support talented pupils from under-represented backgrounds to progress to selective universities.

The Scholars Programme employs doctoral and post-doctoral researchers to deliver programmes of academic enrichment to small groups of pupils, through a combination of university trips, in-school tutorials and online resources.

In partnership with The Brilliant Club and UCL Engineering Education, Gemma Bale (Biomedical Optics Research Lab (BORL) has designed a six-week Key Stage 3 course, Illuminating the Body, for the programme, which uses the MetaboLight public engagement platform to teach Year 8 students about the engineering design process, the application of physical principles to the design of machines, and how scientists interpret data. Having spent several weeks exploring the engineering behind NIRS (near-infrared spectroscopy), the students are then challenged to design and write a 1500 word report on an NIRS system to monitor muscle in athletes.

The course is being delivered by 31 tutors all over the country, reaching almost 400 pupils. Two PhD students from BORL, Isabel de Roever and Pardis Kaynezhad, are delivering the course to Year 8s from the London Academy. Pardis attended a launch event at Royal Holloway on 18 April. She comments:

‘My first experience as a PhD tutor for the Brilliant Club has been extraordinary. It’s such a worthwhile cause and you get so much support and guidance.’

‘I really enjoyed the launch trip at Royal Holloway. It was very encouraging to see how enthusiastic the pupils were about an engineering subject that they were coming to for the first time. After the first tutorial, they had progressed from having no real understanding of Medical Physics and Biomedical Engineering at all to fully appreciating its importance and the need for advancements in these disciplines if lives are to be saved.’

Image above right: Pardis Kaynezhad (far right) with pupils from the London Academy at the Scholars Programme launch event at Royal Holloway on 18 April Image right: school children watch a demo of the Metabolight hand scanner at the Big Bang Fair.

Metabolight

The Metabolight team has been busy travelling around the country introducing hundreds of young people to Medical Physics and Biomedical Engineering.

The project, funded by the Wellcome Trust, uses gummy bears, finger LEDs and interactive games to introduce youngsters to concepts such as the principles of white light, absorption and reflection and oxygenation.

Since the project’s launch in July last year, the team has hosted workshops at the Institute of Physics Teacher Conference at UCL, the London International Youth Science Forum and the National History Museum (as part of an event aimed at inspiring teachers to deliver science in fun and exciting ways).
They have also carried out a number of school visits, including a Year 12 induction for students at Newham College in East Ham, hosted a session as part of UCL’s ‘Engineering Saves Lives’ masterclass series for London schoolchildren, and presented at major science festivals in Norwich, Bradford and Birmingham.

Ilias Tashtidis, Wellcome Trust Senior Fellow and Head of the Multimodal Spectroscopy Group, who leads the MetaboLight programme, comments: ‘It was very exciting for the MetaboLight team to participate in the Big Bang Fair, to show and demonstrate to young people how our research supported by the Wellcome Trust is helping doctors to save newborn lives. I am very proud of the team, who took a short break from their very demanding research activities, to talk to young people and inspire the next generation of biomedical engineers and medical physicists.’

You can find out more about the MetaboLight project, and forthcoming events the team will be attending, at [http://metabolight.org/](http://metabolight.org/) and on Twitter @Metabolight.

**New Scientist Live 2017**

Last year the Institute of Healthcare Engineering put together an exhibition for New Scientist Live, a 4-day event held at London ExCel which attracts over 30,000 visitors.

The event served as both a chance to raise the visibility of our research to industry and government and to inspire the next generation of researchers.

The central element of the display was an eye-catching robotic arm programmed to scan a placenta phantom with a medical endoscope, which attracted lots of people to the stand and helped us to initiate some interesting conversations. The rest of the stand showcased research on imaging biomarkers and surgical sciences, two core disciplines which have relevance to a range of clinical applications.

Visitors to the stand were able to try their hand at being a surgeon, using games console controllers built into a laparoscopic set up to mimic the delicate and precise movements required to perform minimally invasive surgery. Once they had mastered the basics, they were able to progress onto hip replacement surgery via an advanced simulation using a haptic robot with a stylus instead of a surgical device. This provided realistic haptic feedback of the hip being displayed on screen, including tiny ridges and grooves along the bone, and was combined with an augmented reality headset to enhance the immersive experience.

Another demonstration explained how imaging biomarkers can help to detect and diagnose neurological conditions such as Alzheimer’s. Three scenarios, each representing a different stage of disease progression, were presented – a control model, a brain showing mild cognitive impairment and a brain with advanced Alzheimer’s. Visitors were shown MRI scans, clinical reports and 3D models and asked to guess which brain aligned with which diagnosis.

Before and during the event IHE ran a digital marketing campaign, #ScienceThatHeals, which resulted in significant coverage and online interactions from key stakeholders. Overall the event had 136 pieces of coverage and 160 journalists in attendance, demonstrating how useful such events can be in raising the visibility of research.

**Women in Engineering**

Clare Elwell, and four of the department’s female PhD students, Reem Ahmad, Irina Grigorescu, Emma Biondetti and Laura Dempsey hosted a group of all-female students on 15 March, as part of a tour organized by UCL Women Engineers Society.

The event was specifically about how initiatives such as Athena Swan have impacted positively on the UCL environment. The speakers, all at different stages in their academic careers, talked about what attracted them to the field, their areas of research expertise, and what they enjoyed about working in the department (citing a welcoming, inclusive environment, a healthy gender mix, and the chance to work with some of the best researchers in the world).

They also shared advice about how to cope with some of the challenges of being a woman in STEM – including finding great mentors, making full use of the support available, and dealing with ‘imposter syndrome’.
Research articles

Mapping the complexities of the human brain

Juan Eugenio Iglesias (ERC Senior Research Fellow, Translational Imaging Group) reports on an interdisciplinary project set to transform how we understand the substructures of the brain

Most brain structures consist of different substructures with different functions. But current tools only let us study the human brain at the structure level. We are building a set of next-generation human brain atlases and software tools with ex vivo MRI and histological images. These will enable scientists around the world to carry out neuroimaging studies at a higher level of specificity, for example by looking into a sub-field of the hippocampus, rather than the whole hippocampus.

Many brain structures consist of small regions with different connectivity and function, and recent advances in magnetic resonance imaging (MRI) have provided researchers with in vivo images of the human brain of increasing resolution and detail. But the neuroimaging field is still hampered by its reliance on outdated studies which base their analysis on software packages such as FreeSurfer, FSL, SPM and AFNI that are a decade old, and which do not show the brain sub-structures that modern MRI techniques now allow us to see.

This innovative interdisciplinary project brings together computer scientists, MRI physicists, neuroscientists and neuropathologists to build an atlas of the human brain at an unprecedented level of detail. Using MRI scanners at the National Hospital for Neurology and Neurosurgery at Queen Square, we have carefully scanned three brains donated to the Queen Square Brain Bank for a longer period than would be possible in life to yield 3D pictures of unprecedented resolution.

Images right show: Figure 1 (top right): Histology. Figure 2 (middle right): High resolution 3D view of area circled in Figure 1. Figure 3 (lower right): Rendering of tissue block.

The samples will be analysed, sectioned and stained with dyes to reveal microstructural details of the tissue under the microscope, while 3D reconstruction techniques will be developed which will enable us to map the histological sections to the 3D coordinate frame of the MRI.

Both of these modalities will then be combined to create an atlas and companion analysis tools which we will make publicly available to researchers all over the world, enabling them to evaluate brain MRI data at a superior level of structural detail and specificity, and increasing our ability to understand the complexities of the human brain both in health and in disease.
Leading the fight against cancer

Gary Royle, Professor of Medical Radiation Physics, and Co-Chair of the UCL Cancer Domain

Cancer remains one of the major causes of morbidity and premature death worldwide. One in two people in the UK born after 1960 will be diagnosed with some form of cancer during their lifetime. UCL has a proud track record in addressing the societal, biological, technical and health challenges of cancer. The UCL Cancer Domain aims to build on these strengths and engage academics from different fields to advance the understanding, diagnosis, and treatment of cancer, and influence healthcare policy.

The Cancer Research Domain aims to:

• Promote communication, collaboration and cross-disciplinary cancer research.
• Facilitate grant success, research income and access to resources.
• Support career development, education and recruitment.
• Create new strategic partnerships and promote entrepreneurship.
• Raise the profile of cancer research at UCL.

The Cancer Domain is led by three co-Chairs, Daniel Hochhauser, Medical Oncologist, UCL Cancer Institute and UCLH Cancer Division, Alison Lloyd, Cancer Biologist, UCL MRC Laboratory for Molecular Cell Biology and Gary Royle, Medical Physicist, UCL Medical Physics and Biomedical Engineering, as well as a strategic research coordinator Dr David Wiseman, an events and communications manager, Jess Grant, and a steering committee including cancer research heads from across UCL’s Faculties.

In April, the Domain organised and held a half-day meeting around artificial intelligence in cancer, bringing the community together to identify innovative uses of AI and advanced analytic methodologies, and consider societal, medical and ethical implications, as well as the opportunities and challenges around data access. Future events will include a UK Brain Cancer Conference at the Royal Society of Medicine, an interdisciplinary conference on crafting values in cancer care hosted by UCL’s Department of Anthropology, and a two-day Cancer Research Symposium bringing together over 200 researchers and clinicians, which will be held at the Francis Crick Institute.

You can keep up to date with all our news and events at www.ucl.ac.uk/research/domains/cancer
Getting the better of Erhardt Ratdolt

Adam Gibson (Optical and Multimodal Imaging Group, BORL) on using Optical Coherence Tomography to image the first printed edition of Euclid's Elements

Medical imaging is a well understood and very successful part of healthcare. However, imaging has played less of a role in other areas, such as the scientific study of heritage artefacts. The department has a developing collaboration with UCL Special Collections, which houses many fascinating artefacts which raise some interesting imaging challenges.

In 1482, shortly after the invention of modern printing, a printer called Erhardt Ratdolt produced the first printed edition of Euclid’s Elements. The methods he used to print the mathematical diagrams were innovative but remain unknown to historians. It is thought he may have used waste strips of metal, bending them into shape and embedding them into some kind of supportive matrix, such as wax.

Adam Gibson and Peter Munro from Medical Physics and Biomedical Engineering worked with Tabitha Tuckett from UCL Special Collections to find out whether it was possible to image the surface of the pages of the first edition of the Elements, held by UCL Special Collections, so as to gather indications as to how the page was printed.

The team used Optical Coherence Tomography (OCT) to image the shape of the surface of the page. The aim was to reveal depressions in the printed page which might have resulted from the original printing process.

OCT has been one of the biggest successes of biomedical optics in the last thirty years, having gone from a lab invention in the early 1990s to a standard test for imaging the retina and other parts of the body. It has also been used in heritage applications, such as the examination of ancient murals and historical paintings. It is based around an interferometer that detects light scattered back from different boundaries within an object. Here, we were interested in light reflected back from the uppermost surface.

The images seen here show a line through a diagram and some text printed with metal type. Both are slices through a 3D volume, with the slice chosen to be close to the surface of the paper.

The bottom images are taken roughly along the red line shown in the image above. The horizontal direction of the image shows distance along the paper, but the vertical direction shows depth into the printed page. The vertical bands are shadows where the ink on the surface has prevented light from penetrating the paper.

The left hand image, showing a line from a diagram, shows a depression in the surface corresponding to the ink. There is no such dip on the text or the woodcut. We consistently saw this dip in the diagrams but not elsewhere, and never at a distance from the lines, which could suggest that if the metal strips were held in a frame, then the frame was not in contact with the paper.

These results may suggest that Ratdolt used a different method to print the diagrams and the text. If he did print them with metal strips in a mould, he did it in such a way that the mould did not apply significant pressure to the paper. This supports current thinking about Ratdolt’s techniques and further work, perhaps using other techniques borrowed from medical imaging and looking at different copies of the first edition could confirm this.

Image below: OCT images of a line through a diagram and a piece of text.

Image right: Detail of the first page of Euclid’s Elements, part of the Graves Library within UCL Special Collections, which houses over 500 volumes of Euclid’s works.
Beam tracking: multi-modal x-ray phase-based micro-tomography with laboratory sources

Fabio A. Vittoria on behalf of the Advanced X-Ray Imaging Group

X-ray Phase-Contrast Imaging (XPCI) is an innovative technique which can be used to simultaneously measure multiple, independent properties of a sample: attenuation, refraction, and ultra-small-angle scattering (USAXS). While XPCI is routinely used at synchrotrons, its implementation in a laboratory setup is challenging. In a major breakthrough, the Advanced X-Ray Imaging Group has developed an innovative technique, beam tracking, which greatly simplifies the implementation of X-ray Phase Contrast Imaging – or XPCI – in the laboratory, something which is notoriously difficult to achieve.

X-ray imaging is a widely used technique for the investigation of specimens’ internal structure in different fields of application. X-rays travelling through matter are partially attenuated, and the degree of attenuation depends on the sample chemical composition and density. This is the only contrast mechanism used in conventional, attenuation-based, x-ray imaging. Instead, advanced XPCI systems can detect, along with attenuation, two additional signals: refraction and ultra-small-angle scattering (USAXS), the latter of which arises from inhomogeneity of an object on a sub-micrometric scale. XPCI techniques have been used primarily in specialised x-ray facilities such as synchrotrons, or with complex laboratory setups requiring multiple optical elements that have to be mutually aligned with sub-micrometric precision. We have developed an innovative approach, based on a principle similar to the Hartmann wavefront sensor, called beam tracking, and we used it to build a multi-modal laboratory micro-CT system, capable of producing attenuation, phase and USAXS images with micrometric resolution.

In beam tracking, the refraction and USAXS signals are encoded by spatially structuring the beam with a strong amplitude modulator, and specific algorithms are used to decode this information. As an example, Fig. 1 shows a reconstructed CT slice of the attenuation, phase, and USAXS signals obtained from a custom-made sample of three different powders: ground coffee, flour, and icing sugar. The attenuation image (Fig. 1 (a)) would be the only one available with a conventional x-ray micro-CT system, while the phase signal obtained with our method (Fig. 1 (b)) provides better image quality in terms of noise level and resolution. This is particularly evident for the coffee sample, in which the internal structure of individual bean fragments is visible. Figure 1 (d) shows an image obtained from the same coffee powder using a scanning electron microscope, where the same structures observed in Fig. 1 (b) are visible at higher resolution. Sugar and flour, instead, appear homogeneously distributed, with local areas of higher concentration visible in the phase image. While the attenuation and phase signals from sugar are higher than the one from flour, indicating a higher overall density, the USAXS contrast is reversed. This indicates that the average size of the particles is different in the two powders, and it confirms the complementarity of the three signals and their potential for material characterisation.

This is one of the few successful implementations of x-ray phase-contrast micro-CT with a laboratory source. Unlike other attempts, this system does not need to be finely aligned, works with a non-micro-focal laboratory source, is insensitive to beam polychromaticity, and is very stable with respect to setup instabilities (e.g. micro-movements and/or intensity variations of the source focal spot).

**Image below:** Figure 1. Reconstructed slices of attenuation (a), phase (b), and local scattering power (c) of a test sample. (d) shows a high-resolution image of the coffee sample obtained with a scanning electron microscope, highlighting structures similar to the ones that can be seen in (b).
Lighting up babies’ brains

Ilias Tachtsidis (MultiModal Spectroscopy Group)

Between 0.4 million and 1 million children are estimated to die globally each year due to complications related to hypoxic-ischaemic encephalopathy (HIE), more commonly known as ‘birth asphyxia’ – or lack of oxygen at birth. Dr Ilias Tachtsidis, a Wellcome Trust Senior Fellow, Reader in Biomedical Engineering and Head of the MultiModal Spectroscopy Group explains ‘broadband near-infrared spectroscopy’, a novel cot side technology he and his team have developed to safely measure brain oxygenation and brain metabolic status in babies affected by ‘birth asphyxia’, and better predict outcomes after HIE.

The workings of newborn brains affected by hypoxic-ischaemic encephalopathy, or HIE, are complex, and our understanding is largely based on the observations of metabolic changes in the brain, and neural recovery after birth asphyxia.

There is an urgent clinical need to identify those newborns who are most at risk as early as possible, so as to ensure they are able to access early, targeted care and treatment. The availability of early cot side markers of neuronal injury which were able to robustly and accurately predict the likelihood of neurodevelopmental disability in childhood would greatly enhance these babies’ life chances and ongoing quality of life.

The MultiModal Spectroscopy Group, (consisting of myself, Gemma Bale, Frederic Lange, Paola Pinti, Isabel De Roever, Joshua Russell-Buckland, Zuzana Kovacsova, Luca Giannoni and Pardis Kaynezhad), in collaboration with neonatologists from University College London Hospitals (Subha Mitra, Judith Meek, and Nicola Robertson) has developed a novel optical instrument that uses light to see inside a baby’s brain so as to measure brain oxygenation and brain metabolic status.

The technology, known as broadband near-infrared spectroscopy (or Broadband NIRS), uses hundreds of different colours of near-infrared light to probe the brain. White light similar to the headlights in your car is transmitted through fibre optics to the surface of the infant’s head to reveal the colour of the blood in the baby’s brain tissue, thereby measuring oxygenation.

Arterial blood is red (fully oxygenated), while venous blood is blue or purple (less oxygenated). The process is non-invasive, completely harmless, and means that babies can be monitored continuously, at their cot side.

The technology also enables researchers to monitor a range of additional optical signals, including the process whereby glucose and oxygen are converted to energy, thanks to the action of the enzyme cytochrome-c-oxidase or oxCCO (if this process is occurring, the blood changes colour and can be detected via Broadband NIRS).

The team published a paper in the Journal of Cerebral Blood Flow & Metabolism (2017) which reported how Broadband NIRS is able to identify HIE babies at risk of severe cognitive and motor problems within 48 hours of birth using a reactivity index called ‘wavelet semblance’ ranging from +1 to -1. Infants with low wavelet semblance between Broadband NIRS oxCCO and MABP (0 to -1) had a better neurodevelopmental outcome compared to infants with high wavelet semblance (0 to +1). These babies were measured again at 12 months of age, and the ‘wavelet semblance’ carried out 48 hours after birth was found to be a highly accurate predictor of future disability, providing a promising cot side indicator of outcome following HIE.

This research is part of our feasibility study supported by the Wellcome Trust and further information can be found at [http://www.ucl.ac.uk/medphys/research/borl/mms](http://www.ucl.ac.uk/medphys/research/borl/mms) and at [www.metabolight.org](http://www.metabolight.org).

Image above: A comparison of the Broadband NIRS measurement of oxCCO with MABP of two infants following HIE. The ‘mild outcome’ infant demonstrates a low semblance (low metabolic reactivity index) between oxCCO and MABP (lots of blue areas), while the red areas seen in the ‘severe outcome’ infant demonstrate a high semblance between oxCCO and MABP.
Tackling Africa’s health challenges – one app at a time

Terence Leung, Felix Outlaw (Acousto-optic Sensing and Imaging) and Judith Meek (UCLH)

Neonatal jaundice is a major problem in Africa, while rates of anaemia in under 5s in Africa are four times higher than in Europe. Both conditions can be difficult to spot in dark-skinned babies. Terence Leung and colleagues from the Biomedical Optics Research Lab and UCLH are partnering with a teaching hospital in Ghana to develop two ground-breaking smartphone apps which enable health workers to diagnose both conditions quickly and easily – simply by pointing the phone at a patient’s eye.

Neonatal jaundice affects approximately 60% of newborns globally. In Africa, a significant proportion of the population suffers from G6PD deficiency, which increases the risk of hyperbilirubinemia (severe jaundice), a condition that can lead to developmental delay, hearing loss, athetoid cerebral palsy and death.

Jaundiced babies develop yellow discoloration on their skin, and the yellowness of the sclera (the white outer layer of the eyeball) is known to be proportional to the bilirubin level in the blood. To improve diagnosis, we are developing a smartphone app which captures the image of the baby’s eye and analyses the sclera colour.

To further develop this jaundice app and apply it in Africa, we are collaborating with Dr Christabel Enweronu-Laryea, a consultant paediatrician at Korle Bu Teaching Hospital in Accra, Ghana. Following an interview at the Development XChange conference in Washington DC in July 2017, our team was selected as one of 15 finalists from over 550 applications worldwide for the Saving Lives at Birth (Round 7) awards, and we are set to commence our work in Ghana in the summer of 2018.

The World Health Organisation estimates that a quarter of the world’s population is affected by anaemia. Among them, African under-5s are especially at risk of anaemia with a prevalence of 64.6%, almost 4 times higher than that in Europe. In partnership with Dr Enweronu-Laryea’s team at Korle Bu, we are developing another smartphone app to analyse the redness of blood vessels around the eye.

The UCL team travelled to Accra in January to meet their Ghanaian counterparts and launch the anaemia study. So far, 57 sets of data have been collected from Korle Bu Teaching Hospital and the preliminary results are encouraging.

The anaemia study is funded by UCL-EPSRC-GCRF Small Research Grants (2017/18).

Images below: (upper image) PhD student Felix Outlaw demonstrates the smartphone app to doctors and nurses at Korle Bu Teaching Hospital. (lower image) Nurses practise using the app to capture an eye image.
Proton therapy – offering new hope to cancer patients

Stacey Holloway, Megan Wilson & Gary Royle
(Proton and Advanced Radiotherapy Group)

Proton therapy is an advanced type of radiotherapy which is beneficial in a range of cancers. Unlike X-rays, protons can be controlled to stop anywhere inside the cancer, allowing for a higher dose of radiotherapy to be administered and reducing the amount of healthy tissue exposed. But proton therapy is not without its challenges. The Advanced Radiotherapy Group is involved in a number of projects aimed at increasing the accuracy and effectiveness of the treatment and improving the quality of life of patients.

Many cancer patients in the UK undergo radiotherapy as part of their treatment. The greater the radiation dose to the cancer, the greater the chance of cure. But when healthy, non-cancerous tissue is exposed to radiation during the radiotherapy process, it raises the risk of side effects.

Reducing the exposure of healthy tissue is a challenge, and not always possible, which for some patients results in their chance of a cure being decreased in order to avoid health complications. For these patients, proton therapy is an alternative to conventional radiotherapy.

Achieving a uniform radiation dose to the cancer whilst minimising the dose to the nearby healthy tissue is already a challenge in conventional X-ray radiotherapy, but even more so when treating with protons, which are very sensitive to the exact tissue they travel through. When a patient’s position or shape changes we do not know exactly where in the patient the protons will stop, and risk delivering either insufficient radiation to the cancer or too much to healthy tissue.

Our aim is to develop protocols more accurately measuring anatomical changes in patients, so that the correct amount of radiation can be delivered, to the right location, and at the right stage in the treatment process.

Deformable image registration (DIR) is a technique which allows any images taken of the patient during the course of treatment to be deformed to match the overall shape of the high-quality 3D CT scan which is taken at the start of every patient’s radiotherapy treatment.

This enables us to see how the patient anatomy is changing throughout the course of the treatment and to get away with taking lower quality images in the treatment room. The technique can also be used to analyse the dose distribution on the current anatomy and if required, adapt treatment accordingly.

A by-product of the DIR is the Deformation Vector Field (DVF), which shows the size and direction of the anatomical deformation. It is our aim to use these DVFs to develop statistical models of deformation containing probability distributions of population-based geometrical changes, and to see if there is a difference between patients that required a re-plan through their treatment and those who did not.

We have been awarded a Cancer Research UK Development Award for this work and are partnering with UCLH and the Christie Hospital to develop clinical protocols for planning and re-planning in proton therapy as part of our CRUK ART-NET accelerator grant.

We have also been funded by the Science and Technology Facilities Council to develop a ‘Big Data in Radiotherapy’ project in collaboration with particle physicists and medical physicists at Manchester and Cardiff universities. This will aim to produce a method for semi-automated quality assurance of patient image registration for use in clinical settings, where doctors often lack the time to manually assess the quality of every image registration that is performed.

Follow us @ProtonAdvanceRT

Image above: Patient head and neck CT scan showing deformation vector field to illustrate how patients change shape during their radiotherapy treatment.
Motion models for the MR-Linac – an advanced way of treating moving lung tumours

Björn Eiben and Jamie McClelland (Centre for Medical Image Computing)

The Centre for Medical Image Computing has been working with the Institute of Cancer Research to develop a computer algorithm able to track the movement of lung tumours during radiotherapy. They have developed a novel framework for building respiratory motion models which can be used to determine the exact location of the lung, the tumour, and surrounding organs at any point in time, just by measuring a patient’s breathing signals.

In conventional radiotherapy, treatment is planned using images acquired several weeks prior to treatment. The treatment plan assumes that the patient’s anatomy and breathing motion will remain the same throughout the course of treatment, but this is rarely the case, and can lead to suboptimal treatment. Radiotherapy treatment of lung tumours is particularly challenging, since both the lung, the tumour and other organs move every time the patient breathes.

Two global leaders in radiotherapy, Elekta and Philips, developed an MR-Linac, which combines a radiotherapy delivery device (linac) with a magnetic resonance (MR) scanner to enable us to see where a tumour is at every moment during the radiotherapy process. The first MR-Linac prototypes are now in use in a few centres around the world, including the Institute of Cancer Research (ICR) in Sutton, south London.

The MR scanner can be set up so that it images a 2D plane through the patient several times a second showing a cross-section through the tumour and the surrounding tissue, which is then used to precisely direct the radiation onto the tumour. As a result, healthy tissue can be spared from radiation and higher radiation doses can be delivered to the tumour. This process is called tumour tracking and requires the tumour position to be measured in the MR images. The Centre for Medical Image Computing and the Institute of Cancer Research joined forces to examine different algorithms based on different mechanisms – such as image feature tracking, neural networks and image registration – to determine which was the most effective in following tumour position and shape. The registration-based approaches performed best, especially in terms of accuracy and reliability.

But knowing the tumour position in a 2D plane is not sufficient, for example, if we want to calculate unwanted dose delivered to critical organs at risk, such as the heart. For this we need the 3D motion of the full anatomy. Imaging this with the MR scanner directly is currently not possible. To overcome this limitation, the Centre for Medical Image Computing has developed a novel framework for building respiratory motion models which relate the motion of the full 3D anatomy to one or more simple ‘breathing signals’ (see figure). These models can then be used to estimate the precise location of the anatomy at any point in time, just by measuring the breathing signal.

The idea for the MR-Linac is to generate a breathing signal from real-time, continuously acquired 2D images of the lung, and to then use this signal to estimate the motion of the full 3D anatomy using the motion models.

Work is now underway to determine the best way of generating a signal from the 2D slices, to further develop and tailor the general motion modelling framework especially for use on the MR-Linac, and to use the motion estimated by the motion model for planning and guiding treatment delivery on the MR-Linac.

This multi-disciplinary, collaborative work is funded by the Stand Up to Cancer campaign for Cancer Research UK.
Ultrasonic microresonator sensors for photoacoustic imaging

James A Guggenheim (on behalf of the Photoacoustic Imaging Group)

Photoacoustic imaging is an exciting new imaging technique with the potential to greatly enhance our understanding and diagnosis of cancer and other major diseases. However, photoacoustically-generated ultrasound signals are typically much weaker than those encountered in conventional ultrasound imaging. The UCL Photoacoustic Imaging Group has recently developed highly innovative sensors that offer the prospect of significantly increasing the depth and signal-to-noise ratio achievable in photoacoustic imaging; a breakthrough which also has implications for other medical and industrial ultrasound-based techniques.

Photoacoustic imaging is a new biomedical imaging technique based on generating ultrasound waves inside biological tissues using low-energy pulsed light.

It is one of the most promising imaging techniques to have emerged in recent years and offers opportunities for increasing our understanding of basic biological processes and improving the clinical diagnosis and treatment of cancer and other major diseases.

A major outstanding challenge is the need for extremely sensitive detectors due to the fact that photoacoustically-generated ultrasound waves are typically several orders-of-magnitude lower in amplitude than those used in conventional clinical ultrasound imaging.

The UCL Photoacoustic Imaging Group has previously developed highly sensitive sensors exploiting interferometric principles to detect minute ultrasonically-induced optical thickness changes in planar optical cavities. These have produced high quality, high-resolution photoacoustic images such as that in figure (a) which appeared in Nature Photonics in 2015 and shows a tumour and blood vessels [1]. However, the maximum imaging depth is still limited to about 1 cm and further sensitivity gains are needed to image at greater depths.

Now, the group has achieved another major breakthrough in this area. In work published in Nature Photonics in 2017, they have demonstrated for the first time a new type of sensor based upon polymeric planoconcave optical microresonators. By more efficiently confining light inside a planoconcave optical cavity with a very high Q factor, these sensors afford orders-of-magnitude greater sensitivity than conventional piezoelectric receivers of equivalent acoustic element size. They can be constructed on the tips of optical fibres to create miniaturised receivers (figure (b)), and arranged in 2D arrays for imaging (figure (c)). In another recent publication in Biomedical Optics Express they were demonstrated to enable microscopic-scale imaging of microvasculature (figure (d)).

These innovative sensors offer the prospect of significantly increasing the depth and signal-to-noise ratio achievable in photoacoustic imaging as well as potentially extending the capabilities of other medical and industrial ultrasound-based techniques. One example of an emerging application is enabling ultrasound imaging to visualise heart tissues during key-hole surgery. This new technique was demonstrated in Light, Science and Applications in 2017 (see also the “News” section on p.3 of this newsletter).

Figure (a) Tumour image  Figure (b) Minature sensor  Figure (c) Sensor array  Figure (d) Microscopy image
Ryan Lamb
Management Consultant, KPMG
Graduated from MSc Physics and Engineering in Medicine (Medical Image Computing) with Distinction, 2015

I did my undergraduate degree in Physics in South Africa and shared some classes with students studying Medical Physics. I didn’t know much about it, so they introduced me to their Head of Department. We got talking, and I discovered that Medical Physics is a great mix, combining a highly technical discipline and real-world application that directly benefits society.

I trained and qualified as a Medical Physicist in South Africa and worked for a couple of years in public and private hospitals, mostly in radiotherapy but also in nuclear medicine and diagnostic radiology. When I decided I wanted to upskill in medical image computing, UCL was the obvious choice. It is one of the best universities in the world, has a fantastic location, and offers a specialism in Medical Image Computing. When I was fortunate enough to receive a scholarship to UCL, the opportunity was too good to pass up, so I handed in my resignation and went back to being a student again.

I loved studying in central London. It has a fantastic buzz, and there were almost as many countries represented in my class as there were students. I’m still very good friends with some of my former classmates. One is currently qualifying as a radiologist in Oxford and the other works for a radiotherapy start-up in Silicon Valley.

After graduating, I joined KPMG in their Management Consulting team, starting off in Bristol, and then transferring to the London office. I now work within their Government & Healthcare Analytics team, focusing primarily on using data analytics and business intelligence for data strategy, operational improvement and cost savings in healthcare. The skills I learned on the MSc – rigorous, logical thinking, how to structure a problem to reach the desired outcome, and how to frame complex answers in a coherent, accessible way – have been invaluable in consulting, where you are often dealing with a multitude of ambiguous problems on behalf of your clients. Working for a global firm like KPMG is hugely rewarding. You’re always being pushed, always working on new projects, always stimulated and challenged. It’s good to know that between the experience I’m gaining in consulting and the skills I gained at UCL, I have a robust and well-rounded toolkit.

At every stage of my career, I’ve appreciated having mentors who guided and advised me, so I became involved in the UCL Alumni mentoring scheme as a way of giving back to students who may be in a similar position to the one I was in. I’ve met ambitious, interesting students who have been able to teach me new things as well, and it’s great to know that I’ve been able to help someone make a well-informed career decision.

The UCL Alumni Community contains an extensive database of alumni who have gone on to achieve wonderful things across the world – the pure diversity of skillsets and experiences is invaluable and mentees should be able to find someone who has already had a career path similar to one they would like to follow. All they need to do is reach out!

I plan on sticking around in consulting for the time being, and I’m keen to develop my career within the applied data analytics and innovative technology space helping to solve pressing social problems.

What advice would you give to current students, or anyone thinking of studying Medical Physics? Try and gain practical experience and a good understanding of real-world Medical Physics before and during your studies. Reach out to current medical physicists and ask to shadow them – you’ll have a clearer idea of which specialisation you’d prefer, and it will enhance both your time at UCL and your CV for when you graduate. Having practical experience before coming into the programme really helped me to contextualise and ground the coursework.
Janet Cheung  
**Systems Engineer, Medtronic**  
**Graduated with an MSc in Medical Physics and Biomedical Engineering, 2017**

My undergraduate background is in Computer Science and Computer Engineering, but I was always interested in Biomedical Engineering, and keen to better understand both the engineering aspects and underlying principles of medical devices – the ‘why’ and the ‘how’.

I graduated in the Autumn of 2017. Now, I work at Medtronic, a Los Angeles-based medical device company. I am a Systems Engineer in its Diabetes Business Unit, developing product concept designs for insulin pumps and Continuous Glucose Monitoring (CGM) systems. This includes defining the functional and performance requirements of the system, as well as evaluating the risks and potential mitigations concerning the design.

I decided to study at UCL because of my interest in understanding the mechanisms behind medical devices. The material covered in my MSc modules gave me that understanding. Furthermore, as a Systems Engineer, I am engaged in all aspects of the product development lifecycle and often coordinate meetings with different teams. The MSc developed my ability to engage with a diverse demographic and approach problems from different perspectives – soft skills vital not only in one’s career but also in life. As I gain more experience, I hope to take on more leading roles in projects and, eventually, become a Project Manager. In the more immediate future, I want to engage in engineering outreach programs or mentorships and, hopefully, inspire students to pursue careers in the medical engineering industry. I’ve already convinced my sister!

**What single piece of advice would you give to students thinking about studying Medical Physics?**

Keep being curious. Keep asking questions. Don’t be afraid or embarrassed. You will meet people from all kinds of backgrounds and with a variety of life experiences and you will learn about facets of Physics and Engineering that you really don’t expect.

Zihua Su  
**Vice President, Beijing Aerospace Changfeng Co Ltd**  
**Medical Physics and Biomedical Engineering PhD (2008)**

I was always fascinated by the science of image processing, and how it can help people, especially patients. I chose to study Medical Physics because I believed it would provide me with the kinds of skills employers prize. You learn to solve, and manage healthcare-related challenges from a multidisciplinary perspective and the competencies you acquire give you a definite career advantage.

I chose UCL because it is one of the world’s top universities, and the Medical Physics Department is one of the longest-established in the world, with an excellent reputation for its research and teaching.

It was definitely the right decision. I was taught by the very best in the field. My first supervisor was Andrew Todd Pokropek, who made the first PET scanner in Europe, and my second supervisor, Tryphon Lambrou, became my best friend in the lab. I really enjoyed mixing with people from different cultures and backgrounds. UCL is great for that.

After I got my PhD, I did a short internship at Siemens Princeton Research, before returning to China where I took up research positions at Mindray and Siemens. After that, I moved to GE to pursue a marketing position with some extra science and clinical applications. Now I am Vice President of a stock-listed company with two medical businesses directly reporting to me.

**What single piece of advice would you give to students thinking about studying Medical Physics?**

Medical Physics is not easy. But it not only equips you with new knowledge, but the tools, techniques and confidence to apply that knowledge to a wide range of problems. Life is full of challenges, unhappiness, and negative stuff. But you have to get through it, be strong, and prepare yourself for the future. A degree in Medical Physics gives you the resilience you need when the going gets tough.
Stian Johnsen  
**Senior Software Engineer, BrainMiner Ltd**  
MSc Medical Image Computing (2010),  
PhD in Biomedical/Medical Engineering (2016)

I already had an MSc in Computational Science before joining UCL. Towards the end of that degree, I was exposed to biomechanics in medicine as an application for the numerical methods that had made up the bulk of my postgraduate studies, and I really enjoyed it. I was awarded my PhD in 2016. By that time, I was already working as a postdoctoral research associate within the Translational Imaging Group (TIG).

Shortly afterwards, I joined a spinout company started by my former PhD supervisor and two other TIG lecturers, which is mostly owned by UCL Business (the commercialisation company of UCL and its partner NHS Trusts) so in a sense I’ve not left UCL. The image processing methods I learned and applied at UCL, initially as an MSc student of medical image processing and later in my PhD, are an important part of the job, along with some of the data science aspects.

**What single piece of advice would you give to students thinking about studying Medical Physics?**

What I enjoyed most about my time studying at UCL was the freedom and encouragement to explore any methods and topics. Many of the tools and methods I was taught to use in medical image processing are still an important part of my toolkit.

---

Eliza Orasanu  
**Research Scientist, Philips gmbh Innovative Technology, Hamburg, Germany**  
Phd in Medical Imaging (October 2016)

I am currently a Research Scientist at Philips gmbh Innovative Technology in Hamburg, Germany, in the Digital Imaging Research Group, working on brain and lung image segmentation from MR and CT, with applications in cancer radiotherapy treatment planning.

I did my Bachelor’s ‘double’ degree in Physics & Earth and Space Sciences at Jacobs University Bremen in Germany. While there, I did an internship at Fraunhofer Mevis on computational modelling of medical data. It was then when I realised how much I enjoyed medical image analysis.

In 2012, I joined the Medical and Biomedical Imaging CDT at UCL. My PhD project looked at developing computational tools to investigate early brain development in very premature babies.

I think the most important aspect of the CDT was the conferences, and submission deadlines, that supervisors push you to attend and present at. They prepare you for the real world and help you to become a more organised and responsible person. These conferences, which the CDT provides for the students, are also crucial for networking, seeing other people’s work from all over the world and introducing you to industry research.

My career can only go up from here. I want to understand more and more of what’s out there and provide as much support I can to improve healthcare. I think a consultancy position in the medical imaging field is something I am aiming for long term.

**What single piece of advice would you give to students thinking about studying Medical Physics?**

Start thinking about what you want to do next as early as possible, make a plan, and don’t be scared to get out of your comfort zone!
**Starters**

- Omer Ahmad – Clinical Research Fellow
- Edward Bloch – Clinical Training Fellow
- Maurice Burke – Teaching Fellow
- Georgina Cade – Communications Officer
- Ferran Prados Carrasco – Senior Research Fellow
- Charlotte Hagen – RAEng Research Fellow
- Kate Kinninmont – Office Administrator
- Se Li – Project Manager UCL China Cancer Programme
- Callum Little – Clinical Training Fellow
- Katherine Litwinczuk – Administrative Officer and Personal Assistant
- Hani Marcus – Clinical Training Fellow
- Islwyn Shapey – Clinical Training Fellow
- Daniel Taylor – Public Engagement Co-Ordinator
- Lindsay Wright – Comunications and Marketing Manager

**Leavers**

- Millie Abraham – Office Administrator
- Denise Beales – Institute Manager
- Rahima Begum – Research and Development Manager
- Jorge Cardoso – Lecturer
- Alan Cottenden – Professor
- Ioana Dobre – Marketing Officer
- Sarah Jeffrey – Senior Staffing Administrator
- Katie Kony – Communications Manager
- Marc Modat – Lecturer
- Sebastien Ourselin – Professor
- Carole Sudre – Research Fellow
- Tom Vercauteren – Associate Professor
- Weng Sie Wong – Business Development Manager

**Promotions**

- Thomas Allen – Senior Research Associate
- Erwin Alles – Senior Research Associate
- Ben Cox – Reader
- Andrew Melbourne – Proleptic Lecturer in MRI Computational Modelling
- Robert Moss – Senior Research Associate
- Karin Shmueli – Senior Lecturer

**Selected Grants**

- **European Commission Horizon 2020**
  - MRI Contrast Using Microbubbles In Quantitative Susceptibility Mapping £156,363.84 *Dr Karin Shmueli*

- **Cancer Research UK**
  - Clinical translation of photoacoustic imaging for the assessment of head and neck cancers £286,108.79 *Prof Paul Beard*

- **Home Office**
  - Single-Scan collection of 7-dimensional X-ray dataset for enhanced threat detection £372,378.00 *Prof Sandro Olivo*

- **Royal Academy of Engineering**
  - A novel 3D, non-destructive imaging platform for tissue engineering £499,976.00 *Dr Charlotte Hagen*

- **European Commission Horizon 2020**
  - Developing MRI Magnetic Susceptibility-Based Cancer Oxygenation Mapping (SBCOM) and Investigating its Clinical Potential to Measure Hypoxia in Prostate Cancer (PCa) and Head and Neck Squamous Cell Carcinoma (HNSCC) £503,379.39 *Dr Karin Shmueli*

- **National Institute for Health Research**
  - A multi-modality, surgical planning and guidance system to improve the uptake of laparoscopic liver resection £959,524.09 *Dr Matt Clarkson*

- **Medical Research Council**
  - Imaging the functional anatomy of fascicles in the mammalian vagus nerve with neural tracers, electrophysiology and Electrical Impedance Tomography £971,735.29 *Prof David Holder*

- **Perkin Elmer Health Sciences Inc**
  - Plan To Acquire Miniaturize The Edge Illumination (Ei) X-Ray Phase Contrast Imaging (Xpci) Setup To Meet Practical Requirements For A Pre-Clinical Imaging System £119,907.54 *Dr Marco Endrizzi*

- **European Commission Horizon 2020**
  - Advanced Clinical Photoacoustic Imaging Systems Based On Optical Microresonator Detection £1,730,448.80 *Prof Paul Beard*

- **EPSRC**
  - MRI Contrast Using Microbubbles In Quantitative Susceptibility Mapping £99,905.88 *Dr Matt Clarkson*

- **Guarantors of Brain**
  - Longitudinal global and regional atrophy assessment for spinal cord in Multiple Sclerosis £180,000.00 *Dr Ferran Prados Carrasco*
PhD successes

Felix Bragman 28/04/2018
Quantitative Lung CT Analysis for the Study and Diagnosis of Chronic Obstructive Pulmonary Disease

Michael Brown 28/04/2018
Optical and Single Element Transducers for the Generation of Arbitrary Acoustic Fields

Zach Eaton-Rosen 28/09/2017
Using Compartment Models of Diffusion MRI To Investigate the Preterm Brain

Eoin Finnerty 28/03/2018
The Implementation and Application of Quantitative Susceptibility Mapping in the Pre-Clinical Liver

Lebina Kakkar 28/09/2017
Axon Diameter Imaging using Diffusion MRI

Martin Kochan 28/03/2018
Enhancing Registration for Image-guided Neurosurgery

Alexander Mendelson 28/07/2017
Validating Supervised Learning Approaches to the Prediction of Disease Status in Neuroimaging

Arun Niranjan 28/03/2017
Functional Magnetic Resonance Imaging of the Mouse Brain

Phong Phan 28/02/2018
Development of a Multi-Distance, Multi-Channel Broadband Near-Infrared Spectroscopy System to Investigate the Spatial Variation in Cellular Oxygen Metabolism in the Healthy and Injured Adult Human Brains

James Robertson 28/10/2017
Accurate Simulation of Low-Intensity Transcranial Ultrasound Propagation for Neurostimulation

Anna Zamir 28/10/2017
Optimization and new Applications of Edge-Illumination Based X-Ray Phase Contrast CT

Sid Abuchi Chukwuneko 28/02/2018
Cover image by James Guggenheim
These sub-millimetre dome-shaped structures are unique prototypes of a new kind of highly sensitive ultrasound sensor. The colours are created by the mirror they are sitting on, which splits light like a prism.