ANNUAL REPORT 2016

Imperial College Centre for Neurotechnology

CENTRE FOR

NEUROTECHNOLOGY

IMPERIAL COLLEGE LONDON

www.imperial.ac.uk/neurotechnology

DIRECTOR'S FOREWORD

AS PEOPLE LIVE LONGER, SOCIETY FACES HUGE CHALLENGES

with the increasing burden of neurological illness. The nervous system is so complicated that it truly requires a multidisciplinary approach to understand it: classical biology, but also engineering, mathematics, computing, robotics and physics. We need to devise NEW INSTRUMENTATION to measure and manipulate brain activity, helping patients for example rehabilitate or cope with their illness. Also tissue engineering applications, and perhaps synthetic nervous systems are needed. We also need ingenious technological solutions in preventing neurological injury in the first place. We are optimistic though that solutions will be found.

THE CENTRE FOR NEUROTECHNOLOGY at Imperial College London brings together interdisciplinary teams working at the interface between clinically-relevant neuroscience and engineering, to advance our understanding of brain function and produce new technologies in order to reduce the burden of brain disorders on society, ultimately improving the quality of life and health in the UK. Since its launch in 2014, the Centre has become a catalyst a for a focus on research in the area of Neurotechnology, promoting new links between academic and industry researchers, and leading to further research initiatives and development opportunities and contributing to sustainable growth of the UK Neurotechnology sector.

The Centre is also host to the EPSRC Centre for Doctoral Training (the CDT) in Neurotechnology for Life and Health; through this programme we aim to encourage talented young engineers, mathematicians and physicists to engage and work with biologists and medical doctors to help pioneer new neurological therapies and diagnostics.

Imperial College London remains a pioneer in multidisciplinary work. We warmly encourage you to join us.

Prof. William Wisden FMedSci, Dept Life Sciences, Imperial College London

CENTRE FOR NEUROTECHNOLOGY

ABOUT US

The Centre for Neurotechnology encompasses numerous academic departments spanning the three faculties at Imperial College (Engineering, Life Sciences and Medicine), and is complemented by satellite members based at the Brain Network Dynamics Unit at Oxford University, the Francis Crick Institute, and the Sainsbury Wellcome Centre at UCL. The Centre has grown significantly since its launch in 2014, with almost 50 academic staff and almost 40 student members.

MANAGEMENT

Overall leadership and governance of the Centre is provided by the Management Group, which comprises the three Centre Directors, and additional Research Board members drawn from across the three faculties of the College. Alongside the Management Group, Centre's Research Board of 21 determines the scientific direction of the Centre and the mechanisms by which it operates. Academic matters and planning of Centre events and activities are administered by the Centre Operations Board.

External input and guidance for the Centre are provided by the External Advisory Board (EAB) which incorporates high-profile representatives from industry and academia. The Advisory Board meets regularly to review Centre activities, meet with researchers and provide feedback.

Centre for Neurotechnology External Advisory Board meeting, 2016.

From left to right: Paul Matthews (Co- Director), Brian O'Sullivan (Manager, R&D, Process & Technology Development, Stryker Neurovascular), Thomas Stieglitz (Head of Biomedical Microtechnology Laboratory, Bernstein Centre), Caroline Hargrove (Technical Director, McLaren Applied Technologies), Keith Wafford (Principal Research Scientist, Eli Lilly Research Laboratories UK), John White (Professor of Biomedical Engineering, University of Boston), John O'Keefe (Nobel Laureate and Professor of Cognitive Neuroscience, University College London), Simon Schultz (Director), Bill Wisden (Co-Director), Richard Reynolds (Management Group), Robert Ferguson (Industrial Liaison Manager), Lewis Preece (Senior Portfolio Manager, EPSRC), Keith Mathieson (Advisory Board chair, Director of Institute of Photonics, University of Strathclyde). Also attending via skype, Stéphanie Lacour (Chair in Neuroprosthetic Technology, EPFL).

FACILITIES

The Centre benefits from extensive research facilities located across the college, which are available for use by Centre and CDT members and the wider Imperial academic community. High performance computer servers provide data storage and high-performance computing capability for Centre facilities.

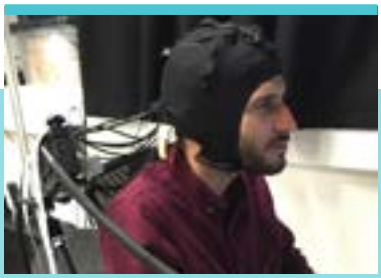
CELLULAR RESOLUTION CONNECTOMICS FACILITY

TissueVision TissueCyte1000 serial two photon tomography platform: this allows axon tracing to be performed, with single cell resolution, in whole mouse brains, or large sections of a human brain.

NON-INVASIVE HUMAN BRAIN SIGNAL RECORDING AND STIMULATION FACILITY

Wireless EMG: allows recordings of muscle activity using surface electromyography (SEMG) electrodes.

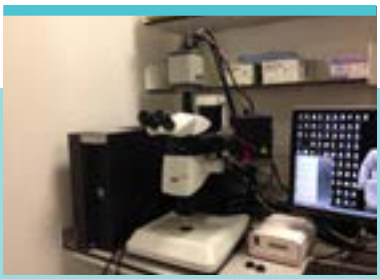
High density, high temporal resolution EEG & EMG: for sampling electrical brain signals at rates of up to 100 kHz.



EEG compatible MRI: allows simultaneous EEG/fMRI experiments as well as simultaneous EEG and brain stimulation experiments.

Multi-channel functional near-IR spectroscopy (fNIRS): allows functional neuroimaging without the need for an MRI scanner.

ORCA-FLASH SCMOS CAMERA



The Hammamatsu ORCA-flash sCMOS camera is a state-of-the-art digital camera for attachment to a microscope for imaging brain activity in animal models.

MULTIPHOTON IMAGING LAB

Two Photon Laser Scanning Microscopy Facility: comprises three Scientifica Multiphoton laser scanning microscopes, two galvanometric microscopes and one resonant scanning microscope.

FLIM MODULE FOR TWO PHOTON MICROSCOPE

A FLIM module installed on a two photon microscope is located at Imperial College's MRC Clinical Sciences Centre, for the use of Centre members.

CENTRE MEMBERS

NEW MEMBERS

PROFESSOR DARIO FARINA DEPARTMENT OF BIOENGINEERING

Dario Farina is the Chair in Neurorehabilitation Engineering at the Department of Bioengineering of Imperial College. The overall aim of his research is to investigate the neural determinants of human movements and to translate this fundamental knowledge into bio-inspired man-machine interfaces to augment, restore, replace, or neuromodulate impaired motor functions. Dario received Ph.D. degrees in automatic control and computer science and in electronics and communications engineering from the Ecole Centrale de Nantes, Nantes, France, and Politecnico di Torino, Italy, respectively. Before moving to Imperial College in 2016, he has been Full Professor at Aalborg University, Aalborg, Denmark, (until 2010) and at the University Medical Center Göttingen, Georg-August University, Germany, where he has been founding Director of the Institute of Neurorehabilitation Systems (2010-2016) and the Chair in Neuroinformatics of the Bernstein Focus Neurotechnology Göttingen (2010-2015). His research group has contributed to several fields in neurorehabilitation, most notably the area of active prostheses (e.g., Science Translational Medicine 8;6(257):257ps12,2014; IEEE Signal Processing Magazine, 29:150-152,2012), with clinical translation (e.g., The Lancet, 385(9983):2183-9,2015; Sci Rep (Nature) 2016;6:34960), and has pioneered bioelectrodes and signal processing methods for human-machine interfacing of motor neurons in vivo that are now adopted by research groups worldwide (e.g., Nature Biomed Eng, 10.1038/s41551-016-0025, 2017; Proc IEEE, 104:353-373 2016).

Dario's research group has pioneered the decoding of activity of spinal motor neurons in humans in vivo with non-invasive recordings. This procedure consists in the deconvolution of the electrical activity of muscles as recorded by hundreds of highly densely spaced electrodes. The muscle electrical activity is in this way used as a bioscreen of the nerve activity due to the one-to-one association between axonal action potentials of the motor neurons and action potentials generated in the innervated muscle fibres. This concept allows the establishment of a window into the output circuitries of the spinal cord. Motor neurons interfaced in this way are the only neural cells whose activity can be exactly decoded in humans non-invasively and routinely in laboratory and clinical settings. ThIs interfacing concept therefore plays a crucial role in addressing fundamental research questions on the neural determinants of movement. Dario's research has indeed focused on applying the pioneered sensors and signal processing methods for motor neuron decoding into basic physiological studies that have revisited classic theories of motor control (for example the concept of motor neuron synchronization and its functional relevance) as well as on translating this interfacing concept into novel neurotechnologies. For the latter applications, Dario's research group and collaborators from the Medical University of Vienna have pioneered a combination of surgical reinnervation of muscles and spinal motor neuron interfacing for dexterous control of upper limb prostheses (Nature Biomed Eng, 10.1038/s41551-016-0025, 2017).

In addition to spinal motor neurons, Dario has also actively worked on several other interfacing designs and translation into clinically-viable technologies for rehabilitation. For example, his work on non-invasive brain-computer interfacing has produced the world's fastest non-invasive Brain-switch, independent of external stimuli. This system has been used in the development of closed-loop brain-computer interfaces specifically designed to induce cortical plasticity in healthy individuals and neurological patients. The concept is based on

associative plasticity induced by the pairing of detection of motor intention with the brain interfacing and peripheral induction of afferent volley (for example, by a robotic mobilization of the limb) triggered by the brain switch. Extensive clinical trials on acute and chronic stroke patients have shown the effectiveness of this new treatment and its potential clinical translation.

Dario's broad research interests also extend to musculo-skeletal models and their use for interfacing humans with exoskeletons and other external devices, to peripheral wearable neuroprostheses for the suppression of pathological tremor, and to the neural determinants of learning and training. All his research is essentially translational, with the main aim of providing new effective treatments and devices to patients. For this purpose, Dario has a large network of industry collaborators and has co-supervised several PhD projects with industry.

RECENT REPRESENTATIVE PUBLICATIONS

- D. Farina et al. "Common synaptic input to motor neurons and neural drive to targeted reinnervated muscles", J Neurosci, In Press
- O. C. Aszmann, I. Vujaklija, A. D. Roche, S. Salminger, M. Herceg, A. Sturma, L. A. Hruby, A. Pittermann, C. Hofer, S. Amsuess, and D. Farina, "Elective amputation and bionic substitution restore functional hand use after critical soft tissue injuries," Sci. Rep. (Nature), vol. 6, p. 34960, 2016.
- D. Farina, A. Holobar, "Characterization of human motor units from surface EMG decomposition", Proc IEEE, 104:353-373 2016
- N. Mrachacz-Kersting, N. Jiang, A. J. T. Stevenson, I. K. Niazi, V. Kostic, A. Pavlovic, S. Radovanovic, M. Djuric-Jovicic, F. Agosta, K. Dremstrup, and D. Farina, "Efficient neuroplasticity induction in chronic stroke patients by an associative brain-computer interface," J. Neurophysiol., 115:1410–1421, 2016.
- M. Sartori, D. G. Llyod, and D. Farina, "Neural Data-Driven Musculoskeletal Modeling for Personalized Neurorehabilitation Technologies," IEEE Trans. Biomed. Eng., 63:879–893, 2016.
- O.C. Aszmann, A.D. Roche, S. Salminger, T. Paternostro-Sluga, M. Herceg, A. Sturma, C. Hofer, and D. Farina, "Bionic Reconstruction Restores Hand Function after Brachial Plexus Injury", The Lancet, 385(9983):2183-9, 2015
- J.A. Gallego, J.L. Dideriksen, A. Holobar, J. Ibáñez, V. Glaser, J.P. Romero, J. Benito-León, J.L. Pons, E. Rocon, D. Farina, „The Phase Difference Between Neural Drives to Antagonist Muscles in Essential Tremor Is Associated with the Relative Strength of Supraspinal and Afferent Input. J. Neurosci., 35:8925-37, 2015
- C.M. Laine, E. Martinez-Valdes, D. Falla, F. Mayer, D. Farina, "Motor Neuron Pools of Synergistic Thigh Muscles Share Most of Their Synaptic Input", J Neurosci. 35:12207-16, 2015
- D. Farina, O. Aszmann, "Bionic Limbs: Clinical Reality and Academic Promises. Science Transl Med. 8;6(257):257ps12, 2014

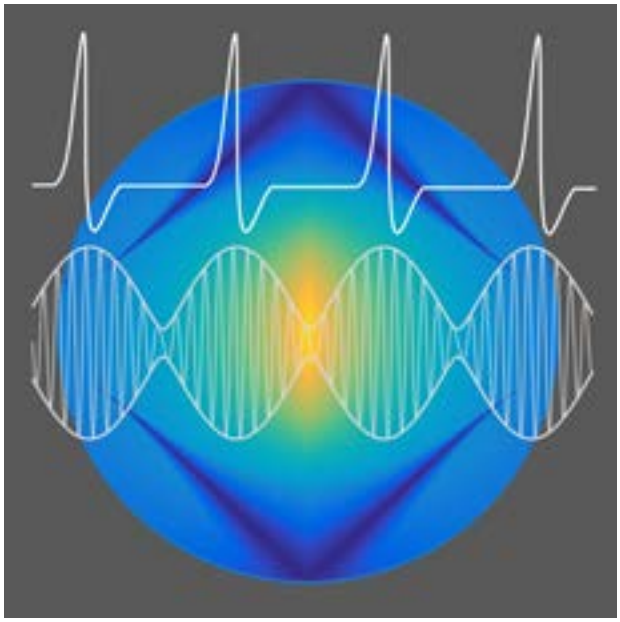
DR NIR GROSSMAN
DEPARTMENT OF ELECTRICAL ENGINEERING

Nir Grossman is a Wellcome Trust-MIT Fellow. The overall aim of his research is to create knowledge and technological innovations in the emerging field of neural prosthetics, with a prominent goal to restore loss of visual functions. Nir received a BSc in Physics from the Israeli Institute of Technology (Technion) and MSc in Electromagnetic Engineering from the Technical University of Hamburg-Harburg (TUHH), Germany. He then moved to the Department of Medicine at Imperial College to conduct PhD training under the supervision of Patrick Degenaar and Christopher Kennard. His PhD thesis focused on the development of Chanelrhodopsin-2 (ChR2) based retinal prosthetics. Following the completion of the PhD Nir was awarded the British BBSRC (Biotechnology and Biological Sciences Research Council) Enterprise Fellow which he conducted at the laboratory of Christofer Toumazou at the Institute of Biomedical Engineering at Imperial College.

A multitude of cognitive and physiological disorders have a debilitating impact on the 'quality-of-life' of the affected patient populace. The majority of such patients are unamenable to any form of treatment as first line (drug) and second line (invasive surgeries) treatments fail. Physical means of brain stimulation, known as 'neuromodulation', represent a tenable, non-pharmacological means to probe and treat the dysfunctional neural networks that underpin brain disorders through direct control of the circuit activity. Implanted electrodes for deep brain stimulation (DBS) have been used around the world to treat patients with severe movement disorders, such as PD, and affective disorders, such as obsessive–compulsive disorder (OCD). DBS is being investigated as a treatment for neurodegenerative diseases such as Alzheimer's disease (AD), with early reports showing an increase in the metabolism of brain regions affected. However, the risk from inserting electrodes into the brain makes exploration of different brain targets difficult and limits the therapeutic impact.

Non-invasive cortical stimulation methods, such as transcranial magnetic stimulation (TMS) and sub-threshold transcranial electrical stimulation (TES) have been used in many human clinical investigations, and TMS is approved by the FDA for patients with treatment-resistant depression. Early reports in healthy humans, show that TES and TMS can boost memory and cognition by enhancing specific oscillatory activity such as slow-wave during non–rapid eye movement (NREM) sleep. However, the ability of TMS or TES to directly stimulate deeper brain structures is obtained at the expense of inducing stronger stimulation of overlying cortical areas, the resulting wider stimulation of which may push on the limits of safety guidelines.

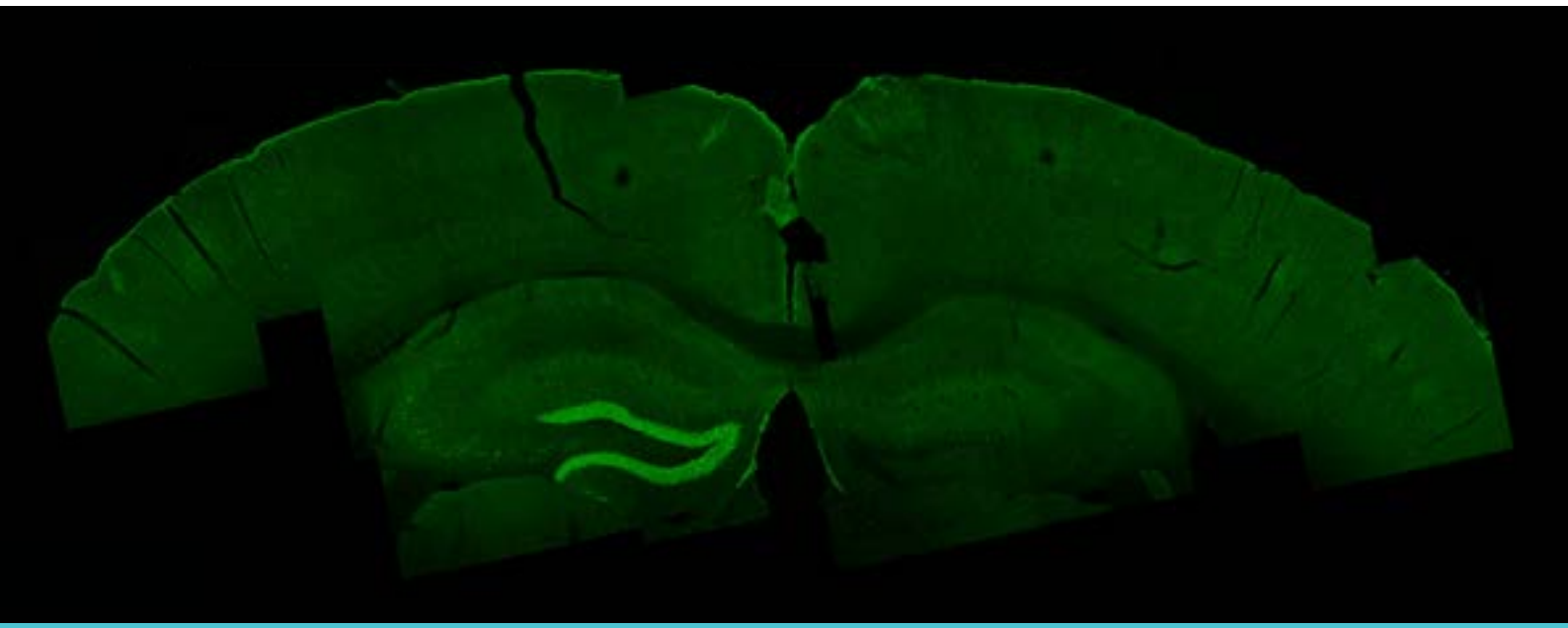
The long-term goal of the lab is to develop neuromodulatory interventions for neuro-degenerative diseases by pioneering new tools and principles to discover mechanisms that can impact the disease pathology via direct modulation of the underlying network activity. In a paper that we recently published, (Grossman et al., Cell 169.6 (2017): 1029-1041), we reported the discovery of a strategy for sculpting the electric fields so as to enable



focal, yet noninvasive, electrical neural stimulation of the brain. We showed that by delivering multiple electric fields to the brain at slightly different kHz frequencies, which are themselves too high to recruit effective neural firing, but for which the difference frequency is low enough to drive neural activity, we can cause neurons to be electrically activated at a focus without driving neighboring or overlying regions. We call this method temporal interference (TI) stimulation, since the interference of multiple electric fields is what enables the focality: neural stimulation will occur only at the region for which the amplitude of the electric field envelope, at the difference frequency, is of great magnitude. We validated the TI stimulation concept via finite element modelling as well as physics experiments, and experimentally verified that neurons in the living mouse brain could follow the interferential electric field envelope, but not the high frequency carrier. We then demonstrated the ability of TI stimulation to mediate activation of hippocampal neurons without recruiting overlying cortical neurons, and steerably probe motor cortex functionality without physically moving electrodes by altering the currents delivered for interference.

We continue to pioneer the TI stimulation technology as well as other advanced neuromodulation tools, and deploy them to discover how entrainment of network activity affects key brain disease drivers, such as homeostatic plasticity and cellular regeneration processes during sleep.

We continue to pioneer neuromodulation tools via scientific exploration of common biophysical principles and rules underpinning the neural processing of electromagnetic stimulation, with natural bridges between advanced computational neuroscience and cutting-edge experiments, ranging from a single neuron cell to human behavior. In addition, together with a network of collaborators, we deploy the tools to discover how entrainment of network activity affects key disease drivers, such as breakdown of homeostatic plasticity and cellular regeneration during sleep.



IMPERIAL COLLEGE ACADEMIC STAFF

Mauricio Barahona, *Chair in Biomathematics, Department of Mathematics*. I am broadly interested in applied mathematics in biological, physical and engineering systems: Dynamics of networks of interconnected nonlinear systems: graph theory and dynamics, theory of synchronization; Algorithms for nonlinear signal analysis; Dimensionality reduction and graph clustering for data science: community detection; Mathematical and computational biology: metabolic and genetic networks (deterministic and stochastic); structural analysis of proteins through graphs.
http://www.imperial.ac.uk/people/m.barahona

Anil Bharath, *Reader in Image Analysis, Department of Bioengineering*. Our group designs algorithms and software architectures for visual inference: converting raw image data into semantic understanding. Our inspiration is biology; our "target" applications range from assistive devices to medical images through to images that are contained within museums or so-called heritage collections. Recently, we have started to work towards robotic applications, particularly where the actions of a robot are informed by visual information. http://www.bicv.org/

Martyn Boutelle, *Professor of Biomedical Sensors Engineering, Department of Bioengineering*. The biomedical monitoring research group is multidisciplinary, embracing both the development of fundamental physical/ analytical science methods and the use of these new techniques in a programme of neuroscience and clinical science research.
http://www.imperial.ac.uk/biomedical-sensors

Stephen Brickley, *Reader in Neurosciences, Department of Life Sciences*. My laboratory studies the control of neuronal excitability and combines biophysical and imaging approaches with computational models to help advance current theories of brain function with a particular emphasis on the control of sleep/wake states.
http://www.imperial.ac.uk/people/s.brickley

Etienne Burdet, *Professor of Human Robotics, Department of Bioengineering*. My main interest is in human-machine interaction. With my group, we use an approach integrating neuroscience and robotics to: i) investigate human motor control and ii) design efficient assistive devices and virtual reality based training for rehabilitation and surgery. A complementary goal is to use current robotics to create novel bioengineering techniques.
http://www3.imperial.ac.uk/human-robotics

Paul Chadderton, *Lecturer, Department of Bioengineering*. The brain is composed of billions of neurons that are intricately connected within small circuits. We are interested in the roles that these circuits play in sensory perception and behaviour. To do this, we record the electrical activity of single cells and small populations, combining advanced electrophysiology and molecular tools to record and manipulate neuronal activity in behaving animals.
https://neuralcircuitsinbehaviour.squarespace.com

James Choi, *Lecturer, Department of Bioengineering*. The research aims of the Noninvasive Surgery & Biopsy Laboratory is to enable physicians to operate on vital organs using incision-less ultrasound-based microsurgical devices and methods. For patients, this implies not only accessible, painless, and infection-free techniques, but also potent therapeutic and diagnostic capabilities never achieved before. The laboratory's current focus is on three research themes: 1: Drug Delivery using Molecular and Cellular Surgery, 2: Drug Distribution Enhancement using Fluid Micropumping, 3: Tissue Elasticity Imaging using Remote Palpation. www.nsblab.org

Claudia Clopath, *Lecturer, Department of Bioengineering*. The lab is broadly interested in the field of neuroscience, especially insofar as it addresses the questions of learning and memory. Learning is thought to change the connections between the neurons in the brain, a process called synaptic plasticity. Using mathematical and computational tools, we model synaptic plasticity across different time scales that reproduces experimental findings. We then study the role of synaptic plasticity, by constructing networks of artificial neurons with plastic synapses.
http://www.bg.ic.ac.uk/research/c.clopath/

Tim Constandinou, *Reader in Neural Microsystems, Department of Electrical & Electronic Engineering*. The Next Generation Neural Interfaces Lab utilises integrated circuit and microsystem technologies to create advanced neural interfaces enabling new scientific and prosthetic applications. The ultimate goal is to develop devices that interface with neural pathways for restoring lost function in sensory, cognitive and motor impaired patients.
www.imperial.ac.uk/neural-interfaces

ABOUT US

Vincenzo De Paola, *Senior Lecturer, MRC Institute of Clinical Science*. We study the regulation of synaptic connectivity in the adult neocortex, a brain region affected in numerous developmental and degenerative diseases as well as acute injuries, which are incurable to date. Specifically, we are trying to understand basic principles of synaptic development and plasticity by visualizing and manipulating both rodent and, more recently, human cortical circuits directly in the living brain.
www.DePaolaLab.com

Simone di Giovanni, *Chair in Restorative Neuroscience, Department of Medicine*. My main area of research is molecular neuroregeneration trying to understand the key molecular mechanisms that control the capacity of axons or adult stem cells to regenerate after central nervous system injuries, including spinal trauma and stroke. In fact, enhancing the regenerative properties of the injured central nervous system may be important to promote recovery of function and limit neurological disability.
http://www.imperial.ac.uk/people/s.di-giovanni

Manos Drakakis, *Professor of Bio-Circuits and Systems, Department of Bioengineering*. Dr Drakakis' group's research activities revolve around two axes: a) "Circuits for Biology" (inspiration drawn by the need for innovative instrumentation as dictated by a specific biological or medical need, and b) "Circuits from Biology" (inspiration drawn by operational, architectural and/or anatomical characteristics encountered in natural information processing systems).
http://www.bg.ic.ac.uk/research/e.drakakis/

Aldo Faisal, *Senior Lecturer in Neurotechnology, Department of Bioengineering/Department of Computing*. Dr Faisal's lab combines cross-disciplinary computational and experimental approaches to investigate how the brain and its neural circuits are designed to learn and control goal-directed movements. The neuroscientific findings enable the targeted development of novel technology for clinical and research applications (Neurotechnology) for a variety of neurological/motor disorders and amputees.
http://www.faisallab.com/

Dario Farina, *Chair in Neurorehabilitation Engineering, Department of Bioengineering*. My research focuses on biomedical signal processing, neurorehabilitation technology, and neural control of movement.
http://www.imperial.ac.uk/people/d.farina

ABOUT US

Amanda Foust, *RAEng Research Fellow, Department of Bioengineering*. The ability to manipulate and track neuronal communication is essential to understanding the mechanisms underlying our sensations, perceptions, thoughts, emotions and actions. With a growing toolbox of optical dyes, genetic sensors and actuators, Neuroscience has made science fiction-scale progress toward realizing this important prerequisite for neural circuit reverse engineering. A parallel revolution in photonics research is taking shape to exploit the full potential of photo-molecular tools for brain circuit interrogation. My goal is to engineer bridges between recent optical technology and Neurophysiologists endeavouring to close the loop between theory and experimentation.
http://www.imperial.ac.uk/people/a.foust

Giorgio Gilestro, *Lecturer in Systems Biology, Department of Life Sciences*. My current research is aimed at elucidating the enigmatic function(s) of sleep using a combination of neurobiology, genetics and bioinformatics. Most of the work is carried on using Drosophila melanogaster as model system, but some projects aim at addressing novel ways of study sleep in humans too.
https://lab.gilest.ro/

Dan Goodman, *Lecturer, Department of Electrical & Electronic Engineering*. The aim of my research is to uncover the principles underlying neural computation with precisely timed spikes. This is a form of computation specific to the brain, being radically different to both digital and analogue computation. I have developed several software tools for working with spiking neurons, notably the "Brian" spiking neural network simulator. My focus is on sensory processing of complex, realistic stimuli, primarily in the auditory system.
http://neural-reckoning.org/

Nir Grossman, *Research Fellow (Wellcome Trust), Department of Electrical & Electronic Engineering*. Nir develops neuromodulatory interventions for brain disorders by pioneering new tools and principles to impact the disease pathology via direct modulation of the underlying aberrant neural activity. His research drives innovation through rigorous scientific exploration of common biophysical principles and rules underpinning the neural processing of electromagnetic stimulation, using natural bridges between advanced computational neuroscience and cutting-edge experiments, ranging from a single neuron cell to human behaviour. http://www.imperial.ac.uk/people/nirg

Adam Hampshire, *Senior Lecturer in Restorative Neurosciences, Department of Medicine*. The overarching aim of my research is to derive a better understanding of how task active networks in the human brain support key aspects of cognition such as attention, motor response inhibition, working memory, planning and reasoning, and how these aspects of cognition are affected in the pathological brain. I apply a wide range of techniques in pursuit of this aim including functional and structural brain imaging, genotyping, machine learning and computational modelling.
http://www.imperial.ac.uk/people/a.hampshire

Thomas Knöpfel, *Chair in Optogenetics and Circuit Neurosciences, Department of Medicine*. My lab specializes on light and genetics-based functional imaging approaches to better understand how behaviour emerges from the electrical activities of neuronal circuits. Using genetically encoded indicators, we pursue a mesoscopic scale imaging approach that bridges cellular and system levels of understanding.
http://knopfel-lab.net/

Mirko Kovac, *Senior Lecturer, Department of Aeronautics*. Dr Mirko Kovac is Director of the Aerial Robotics Laboratory and Senior Lecturer in Aero-structures at Imperial College London. His research group focusses on the development of novel, biologically inspired flying robots for distributed sensing in air and water and on autonomous robotic construction for future cities. Dr Kovac's particular specialisation is in robot design, hardware development and multi-modal robot mobility.
http://www.imperial.ac.uk/aerial-robotics

Andrei Kozlov, *Lecturer, Department of Bioengineering*. Our research, broadly speaking, focuses on how the auditory system, a keystone of human communication, achieves its remarkable sensitivity, selectivity, and invariance. We investigate both how the inner ear converts sounds into electrical signals, and how auditory cortex interprets these signals.
http://www.kozlovlab.com

Holger Krapp, *Professor of Human Robotics, Department of Bioengineering*. My main interest is in human-machine interaction. With my group, we use an approach integrating neuroscience and robotics to: i) investigate human motor control and ii) design efficient assistive devices and virtual reality based training for rehabilitation and surgery. A complementary goal is to use current robotics to create novel bioengineering techniques.
http://www3.imperial.ac.uk/human-robotics

ABOUT US

Robert Leech, *Senior Lecturer, Department of Medicine*. Robert Leech is a Senior Lecturer within the Division of Brain Sciences and is a member of the Computational, Cognitive and Clinical Neuroimaging Laboratory. His research is inherently multi-disciplinary, integrating neuroscience, psychology and computer science to better understand the healthy and pathological brain.
https://www.c3nl.com/

Nick Long, *Sir Edward Frankland BP Chair -Inorganic Chemistry, Department of Chemistry*. The Long Group have expertise in applied synthetic inorganic and organometallic chemistry. Research interests focus on transition metal and lanthanide chemistry for the synthesis of functional molecules, homogeneous catalysis and in recent years, probe design and novel methodologies for biomedical imaging.
http://www.ch.ic.ac.uk/long/

Danilo Mandic, *Professor of Signal Processing, Department of Electrical & Electronic Engineering*. Prof Danilo Mandic specialises in statistical signal processing, brain computer interface, and ultra-wearable physiological sensing. His ear-EEG technology is the first to make possible the recording of both EEG and vital signs from within the ear canal, with applications in continuous 24/7 monitoring of brain and body function outside the clinic.
http://www.commsp.ee.ic.ac.uk/~mandic/index.htm

Paul Matthews, *Edmond and Lily Safra Chair, Department of Medicine.* Paul Matthews, OBE, MD, DPhil, FRCP, FMedSci is Head of the Division of Brain Sciences in the Department of Medicine of Imperial College, London. He has recently been named as Director of the UK Dementia Research Institute at Imperial College. His research is directed towards novel approaches for human therapeutic target validation, low cost clinical trial design and stratified medicine.
http://www.imperial.ac.uk/people/p.matthews

Dipankar Nandi, *Visiting Reader in Neurosurgery, Department of Medicine.* My clinical and research interests lie in the fascinating confluence of stereotactic functional neurosurgery (deep brain stimulation, DBS), the neurophysiology (local field potentials) of movement disorders (PD, essential tremor, MS tremor, dystonia), treatment resistant depression and chronic central pain (post-stroke pain, cluster headaches, other intractable neuropathic pain syndromes) and the electrical-brain interface generated by the DBS electrode in vivo.
http://www.imperial.ac.uk/people/d.nandi

Mark Neil, *Professor of Photonics, Department of Physics*. With a broad academic background, it is hardly surprising that Mark Neil often finds himself working in multidisciplinary projects alongside engineers, medics, chemists and biologists and on problems as diverse as studying the inner workings of cancer cells to the manufacture of mirrors for forthcoming generations of extremely large astronomical telescopes. While imaging, microscopy and metrology are the mainstays of his work, underpinning this are technologies that enable the control of light by computer that are now changing how we view potential applications of optical systems. http://www.imperial.ac.uk/people/mark.neil

Kenji Okuse, *Senior Lecturer, Department of Life Sciences*. Research in our laboratory focuses on the molecular mechanism of pain pathways. We employ primary cultures of sensory neurons and macrophages, live cell imaging, and molecular biology. 1. Roles of neuropeptide VGF and its receptor in neuropathic pain; 2. Roles of macrophages in hyper-excitation of sensory neurons; 3. The mechanism of hypersensitisation of sensory neurons in chronic pain conditions.
http://www.imperial.ac.uk/people/k.okuse

Tobias Reichenbach, *Lecturer, Department of Bioengineering*. Dr Reichenbach is interested in problems at the interface of physics and biology. He uses ideas from theoretical physics, mathematics, and computer science to investigate how biological systems function, from the molecular and cellular level to organs and the nervous system. Much of Dr Reichenbach's research focuses on hearing. The auditory system showcases an astonishing performance regarding its sensitivity, dynamic range, and frequency resolution. Dr Reichenbach aims to identify the underlying biophysical specializations, and investigate how the ear's strategies can be employed in speech and hearing technology.
http://www.bg.ic.ac.uk/research/reichenbach/

Richard Reynolds, *Professor of Cellular Neurobiology, Department of Medicine*. Professor Reynolds' research focuses on understanding the pathogenetic mechanisms involved in demyelination and neurodegeneration in multiple sclerosis and the development of novel therapeutic pathways. This has involved extensive research on human brain tissue from the UK MS Society Tissue Bank, which he set up in 1998, and the development of novel models to investigate molecular pathways of disease. Through collaborations with the biopharmaceutical industry this work has led to a number of important translational approaches to treating clinical progression in MS.
http://www.imperial.ac.uk/medicine/multiple-sclerosis-and-parkinsons-tissue-bank/

Esther Rodriguez-Villegas, *Professor in Low Power Electronics, Department of Electrical & Electronic Engineering*. Esther Rodriguez-Villegas holds the chair of Low Power Electronics in the Department of Electrical and Electronic Engineering, Imperial College London, where she leads a multi-disciplinary team of thirteen PostDocs and PhD students. Her most recent research interests are focused on wearable sensors for physiological monitoring and low-power integrated circuits with a focus on healthcare applications.
http://www.imperial.ac.uk/people/e.rodriguez

Simon Schultz, *Reader in Neurotechnology, Department of Bioengineering*. The Schultz Lab works at the interface between engineering and neuroscience. Our aim is to understand how information is processed by mammalian neural circuits underlying perception, action and memory. Understanding how "cortical circuits" process information may help us to understand how it dysfunctions in neurodegenerative disorders such as Alzheimer's Disease, and also aids in the design of novel computational devices.
http://www.schultzlab.org/

Barry Seemungal, *Honorary Clinical Senior Lecturer, Department of Medicine*. Barry Seemungal (PhD FRCP) is a neurologist who researches the brain mechanisms of vestibular function and dysfunction, with a focus on vestibular cognition. Dr Seemungal has received research funding from the Academy of Medical Sciences, the Medical Research Council UK, the EPSRC, Imperial College Charities and the Friends of St Mary's.
http://www.imperial.ac.uk/people/b.seemungal

David Sharp, *Professor of Neurology, Department of Medicine*. David Sharp is an NIHR Research Professor and honorary consultant neurologist with a special interest in traumatic brain injury. He runs a multidisciplinary traumatic brain injury clinic at Charing Cross hospital and directs a program of research investigating the impact of traumatic brain injury on cognitive function. His research uses advanced neuroimaging to study brain network function, both in healthy individuals and following brain injury. By understanding changes in network function he hopes to guide the development of novel treatment strategies for patients with cognitive impairment following brain injury.
http://www.imperial.ac.uk/people/david.sharp

Molly Stevens, *Professor of Biomedical Materials & Regenerative Medicine, Department of Materials/ Department of Bioengineering*. Professor Stevens has a large and extremely multidisciplinary research group of students and postdocs/ fellows. The group is focused on both high quality fundamental science and translation for human health. Research in regenerative medicine within her group includes the directed differentiation of stem cells, the design of novel bioactive scaffolds and new approaches towards tissue regeneration.
http://www.imperial.ac.uk/people/m.stevens

ABOUT US

Richard Syms, *Professor, Department of Electrical & Electronic Engineering*. Richard Syms has been developing miniaturized dual numerical aperture confocal scanning microscope systems for applications in optogenetics.
http://www.imperial.ac.uk/people/r.syms

Mengxing Tang, *Reader in Biomedical Imaging, Department of Bioengineering*. Dr Tang leads the Ultrasound Laboratory for Imaging and Sensing (ULIS). His current research mainly focuses on developing new imaging techniques of ultrahigh temporal resolution (up to tens of thousands of frames per second) and spatial resolution (down to tens of microns at multi-centimeter depth) using ultrasound and signal processing, as well as new image analysis techniques, for quantifying physiological flow, tissue perfusion, tissue mechanical properties and molecular information in cancer, cardiovascular and neurological diseases. http://www.bg.ic.ac.uk/research/m.tang/ulis/

Ravi Vaidyanathan, *Senior Lecturer in Bio-Mechatronics, Department of Mechanical Engineering*. Mechatronics is the synergistic combination of precision engineering, electronic control, and systems thinking in the design of products and manufacturing processes. Bio-Mechatronics may be viewed as its extension fused with influence from biological systems; i.e. mechatronic systems designed based on inspiration from neural and physiological systems. Our research focuses on mechanisms of sensory-motor control, specifically with respect to systems-level coupling between mechanics and neurophysiology. http://www.biomechatronicslab.co.uk/

Ramon Vilar, *Professor of Medicinal Inorganic Chemistry, Department of Chemistry*. Our research focuses on the synthesis and biomedical applications of metal complexes and supramolecular assemblies. In particular, we are interested in understanding the interactions of metal complexes with DNA and proteins, and in the development of novel molecular probes for sensing and bio-imaging.
http://www.imperial.ac.uk/vilar-research-group/research/

Bill Wisden, *Professor of Molecular Neuroscience, Department of Life Sciences*. Research interests and techniques include: Neuroscience: molecular biology; transgenics, neuroanatomy, physiology, behaviour; Mechanisms of sleep; Hypothalamic function: the regulation of neurons which make histamine: the tuberomammillary nucleus and sleep regulation; other neuromodulators which regulate sleep.
http://www.imperial.ac.uk/life-sciences/research/research-themes/anaesthesia-sleep-and-pain/

RESEARCH FELLOWS

Peter Hellyer, *Sir Henry Wellcome Postdoctoral Fellow, Department of Bioengineering*. Peter's research uses a combination of structural and functional magnetic resonance imaging (fMRI and DTI) to study the relationship between the dynamic functional activity of the brain, neural structure and cognition. Using tractography based on Diffusion Tensor Imaging to map the structural connectivity of the healthy brain, he uses novel computational modelling constrained by the white matter structure of the brain combined with Machine Learning (MVPA) and data compression approaches such as Independent Component Analysis (ICA), to decompose and predict the dynamical properties the human brain.
http://www.imperial.ac.uk/people/peter.hellyer

RESEARCH STUDENTS

COHORT 1 (2014)

Cher Bachar (Bioengineering)
High-throughput Visualization and Computational Consequences of Increased Synaptic Plasticity and Axon Regeneration in the Living Aged Brain
Supervisors: Dr Vincenzo De Paola, Dr Claudia Clopath, Dr Anil Bharath

Tamara Boltersdorf (Chemistry)
Designing novel imaging probes for targeting inflammatory lesions in brain disorders
Supervisors: Prof Nicholas Long, Dr Felicity Gavins

Rajinder Lotay (Bioengineering)
Virtual physiotherapy for assessment and training of arm function
Supervisors: Prof Etienne Burdet, Dr Paul Bentley

Diana Lucaci (Life Sciences)
High-resolution mapping of age-related functional changes in cortical connectivity
Supervisors: Dr Stephen Brickley, Dr Paul Chadderton, Prof William Wisden

Peter Quicke (Bioengineering)
Optical Measurement of Neuronal Connectivity using a Genetically Encoded Voltage Indicator
Supervisors: Dr Simon Schultz, Prof Mark Neil, Prof Thomas Knöpfel

Benedikt Schoenhense (Bioengineering)
Machine learning and human adaptability: towards a hierarchical model of executive cognition and brain function
Supervisors: Dr Aldo Faisal, Dr Adam Hampshire

Hugo Weissbart (Bioengineering)
EEG assessment of spoken language processing in aphasia
Supervisors: Dr Tobias Reichenbach, Dr Robert Leech, Prof Etienne Burdet, Prof Richard Wise

Aidan Wickham (Bioengineering)
Wearable wireless sensor arrays to detect the progression of amyotrophic lateral sclerosis (ALS)
Supervisors: Prof Martyn Boutelle, Dr E M Drakakis)

Georgios Zafeiropoulos (Bioengineering)
Automated Neonatal EEG Early Warning System based on novel signal analysis tools in the field and/or novel features
Supervisors: Dr E M Drakakis, Prof D Edwards

COHORT 2 (2015)

Tiffany Chan (Chemistry)
Ultrasound technology to deliver novel theranostic agents to malignant brain tumours
Supervisors: Ramon Vilar, James Choi, Amin Hajitou, Matt Williams

James Clarke (Mechanical Engineering)
Integrated Sensor Suite to Investigate Neurological Dysfunction in Balance
Supervisors: Ravi Vaidyanathan, Alison McGregor; Collaborators: Rob Hart, Caroline Hargrove (McLaren Applied Technologies)

Darije Custovic (Medicine)
Neural network mechanisms of inhibitory and attentional control
Supervisors: Adam Hampshire, Claudia Clopath

Sofia Dall'Orso (Bioengineering)
Robot-assisted fMRI investigation of learning in newborn infants
Supervisors: Etienne Burdet, Daniel Rueckert, David Edwards
Collaborator: Tomoki Arichi (KCL)

Andrea Fiorentino (Bioengineering)
Computational technology towards future therapies for itchness via neuro-skin interactions
Supervisors: Dr Reiko Tanaka, Dr Claudia Clopath, Dr Paul Chadderton

Lewis Formstone (Mechanical Engineering)
Lesion-symptom mapping using motion-tracking: How neural trauma impacts motor function
Supervisors: Ravi Vaidyanathan, Paul Bentley, Etienne Burdet, Alison McGregor

Patricia Gallego (Medicine)
Axo-glial pathology in Multiple Sclerosis and its effects on neurotransmission: development of a computational model
Supervisors: Richard Reynolds, Aldo Faisal, Kambiz Alavian

Carl Lubba (Bioengineering)
Peripheral nerve decoding algorithms for bioelectronic medicines
Supervisors: Simon Schultz, Nick Jones
Collaborator: Victor Pikov (Galvani Bioelectronics)

Gerald Moore (Life Sciences)
Developing technology to enable macroscopic imaging of neuronal connectivity to quantify changes during health and disease
Supervisors: Dr Stephen Brickley, Simon Schultz

Konstantinos Petkos (Bioengineering)
ReBooT: Restoring Brain Operation with Technology; Microelectronics to enable an open source instrument for exploring closed loop neural systems
Supervisors: Emm Mic Drakakis; Collaborators: Timothy Denison (Medtronic Neuromodulation [U.S.]), Peter Brown (Oxford University)

Tom Robins (Bioengineering)
Towards whole brain functional imaging in freely moving subjects
Supervisors: Mengxing Tang, Paul Chadderton

COHORT 3

Tunvez Boulic (Bioengineering)
Biologically inspired computation for real-time motor learning
Supervisors: Paul Chadderton, Claudia Clopath

Matthew Copping (Bioengineering)
Development of a noninvasive and localised blood-brain barrier opening system for the treatment of Alzheimer's Disease
Supervisors: James Choi, Magdalena Sastre

Giuseppe Gava (Bioengineering)
Information theoretic analysis tools for studying the cellular assembly of memory
Supervisors: Simon Schultz, David Dupret (University of Oxford), William Wisden

Bryan Hsieh (Life Sciences)
Microdevices to investigate sleep and temperature regulation in mice
Supervisors: Nick Franks, Tim Constandinou, William Wisden

Sihao Lu (Bioengineering)
Characterising receptive fields of astrocytes in auditory cortex
Supervisors: Andrei Kozlov, Simon Schultz, Claudia Clopath

Sebastian Mancero (Mechanical Engineering)
Wearable Force-Feedback Interface supporting in vivo Brain-Robot Interface
Supervisors: Ravi Vaidyanathan, Etienne Burdet
Peter Brown (Oxford University)

Thomas Martineau (Mechanical Engineering)
Neural implants for brain-robot interface
Supervisors: Ravi Vaidyanathan
Peter Brown (Oxford University)

Sebastian Popescu (Medicine)
Measuring brain and body biological age to predict health outcomes and disease risk during ageing
Supervisors: David Sharp, Ben Glocker, Paul Matthews, James Cole

Martin Priessner (Chemistry)
Role of copper ions in the toxicity of α-synuclein in Parkinson's disease
Supervisors: Ramon Vilar, Liming Ying, Alfonso De Simone, Magdalena Sastre

Kaja Ritzau-Reid (Materials)
Conductive polymer platforms for the integrated in vitro investigation of neural networks
Supervisors: Molly Stevens, Ramon Vilar

Jeevan Soor (Bioengineering)
Engineering fast, flexible, precise, and parallel light sculpting for neural circuit elucidation
Supervisors: Amanda Foust, Simon Schultz, Mark Neil

Lotte Weerts (Electrical & Electronic Engineering)
Learning to hear with plasticity across multiple timescales
Supervisors: Daniel Goodman, Claudia Clopath

ALIGNED STUDENTS

Paolo Angeles, PhD (Mechanical Engineering)
Research area: Design and development of medical devices using external sensors and the statisical modelling and machine learning aspect of data analysis
Supervisors: Ravi Vaidyanthan

Chris Caulcrick, PhD (Mechanical Engineering)
EPSRC ICASE studentship: *Quasi-Passive Human-Exoskeleton System Modelling*
Supervisors: Ravi Vaidyanathan, Alison McGregor, Caleb Swade (McLaren Applied Technologies)

Romy Lorenz, PhD (Medicine)
Research area: I investigate the feasibility of an fMRI-informed EEG-based neurofeedback system for TBI patients.
Supervisors: Rob Leech

Christian Martin, PhD (Bioengineering)
Wellcome Trust Fellowship: *Information transmission through cross-frequency coupling: revealing the frequency structure of information exchange in the brain*
Supervisors: Simon Schultz

Sam Wilson, PhD (Mechanical Engineering)

Research area: *The Natural User Interface*
Supervisors: Ravi Vaidyanathan, Alison McGregor, R Harkins (US Naval Postgraduate School)

Muhammad Ihsan, MRes Neurotechnology
Brain functional imaging with ultrasound
Supervisors: Mengxing Tang, Paul Chadderton

Martyna Stachaczyk, MRes Neurotechnology
Interactive tasks for the assessment of sensorimotor control
Supervisors: Etienne Burdet, Paul Bentley

CENTRE FOR NEUROTECHNOLOGY

COLLABORATION

The Centre has a large network of national and international collaborators from industry, academia and the health sector which is constantly evolving.

SATELLITE GROUPS

We interact with satellite groups at the Oxford MRC Brain Network Dynamic Group, Francis Crick Institute and Sainsbury-Wellcome Centre for Neural Circuits and Behaviour at UCL., through joint supervision of students, involvement in the Centre Research Board and reciprocal organisation of events, such as symposia and seminars.

HEALTH SECTOR

The Centre and CDTN have attracted considerable NHS involvement, with the Imperial College Healthcare NHS Trust Biomedical Research Centre agreeing to fund approximately one studentship per cycle. NHS staff are involved in numerous other projects also, including projects on monitoring of brain injury and rehabilitation after stroke.

EXTERNAL PARTNERS

The Centre and CDT continue to benefit from links with industry partners through studentship funding and joint supervision of Centre and CDTN projects (McLaren Applied Technologies, Medtronic, Galvani Bioelectronics), as well as through Advisory Board membership (Stryker, Eli Lilly).

Our industry partners bring direct advantages to the Centre and the projects they are involved with through access to technology platforms, technical expertise and use of facilities, discussion of commercialisation of technology and direct supervision of students. Students from the CDTN in particular benefit greatly through interaction with industry partners; in 2016 collaboration with partner Galvani Bioelectronics (formerly part of GlaxoSmithKline) enabled one of our CDTN students to be involved in development of an algorithm that was rolled out across Galvani's network and into their intramural research programme. In addition, collaborative work with McLaren Applied Technologies has resulted in outreach covered by BBC Click and the Financial Times, which would not have been possible without the industry involvement.

The start of the CDTN student internship programme in 2016 promises to strengthen links with industry and external academic partners further.

EPSRC Engineering and Physical Sciences Research Council

McLaren

wellcome

MRC Medical Research Council

stryker

GALVANI BIOELECTRONICS

NIHR Imperial BRC Translating research into patient benefits

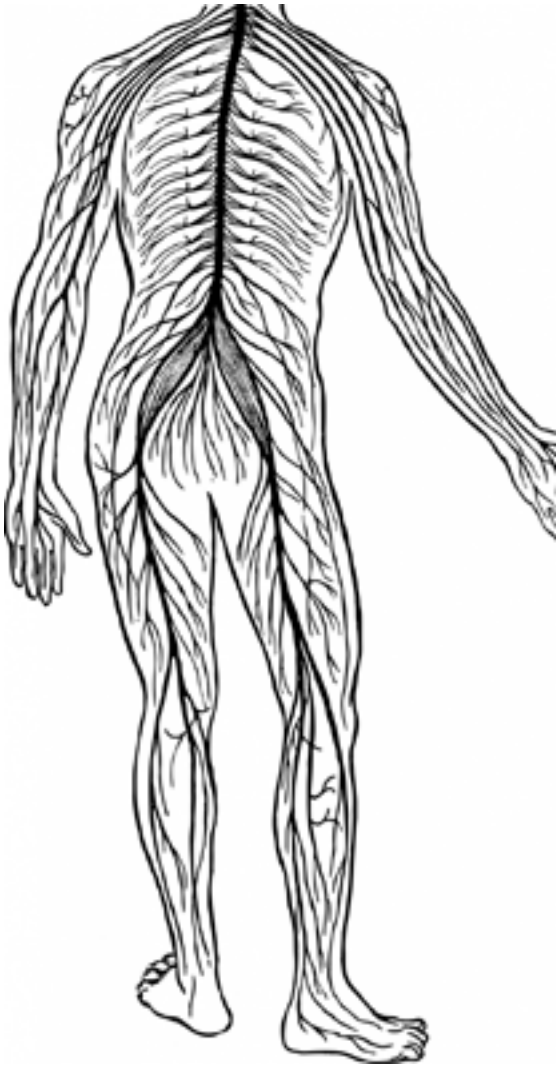
Scientifica

Medtronic

Lilly

THE FRANCIS CRICK INSTITUTE

NEUROTECHNOLOGY SEMINARS



Collaborations with academic institutions are enhanced by inviting leading international and national external speakers to present in Centre seminars and annual research symposia.

Presentations hosted by the Centre in 2016 included:

MARCH 2016: MINI-SYMPOSIUM ON ALZHEIMER'S DISEASE:
Francesco Tamagnini, University of Exeter Medical School
Roxana Carare, University of Southampton

MAY 2016: MINI-SYMPOSIUM: "THE ADDICTIVE ENGRAM"
David Dupret, MRC Brain Network Dynamics Unit, Oxford University
Christian Lüscher, University of Geneva

MAY 2016: MINI-SYMPOSIUM ON SPINAL CORD INJURY
Julian Taylor, Research Director, Stoke Mandeville Spinal Research
Bethel A Osuagwu, Stoke Mandeville Spinal Research/University of Glasgow

JUNE 2016: MINI-SYMPOSIUM ON DECISION
Peter Dayan, Gatsby Computational Neuroscience Unit, UCL
Mark Humphries, University of Manchester

SEPTEMBER 2016: JOINT CENTRE/DEPT OF BIOENGINEERING SEMINAR
Applications of Gold Nanoparticles in Infrared Neural Stimulation, Paul Stoddart, Swinburne University of Technology, Australia

OCTOBER 2016: MINI-SYMPOSIUM ON AUDITORY PROCESSING
Richard Turner, Department of Engineering, University of Cambridge
Daniel Bendor, Division of Psychology and Language Sciences, UCL

NOVEMBER 2016: JOINT CENTRE/DEPT OF BIOENGINEERING SEMINAR
Sensory processing in Larval Zebrafish, Ethan Scott, University of Queensland

CENTRE FOR NEUROTECHNOLOGY

RESEARCH

Research themes in the Centre include ***Microelectronics, devices & biosensors, Optical & genetic neurotechnology, Computational modelling & data analysis tools, Neuroprosthetics & neural interface technology, Robotics & human-machine interaction***, and ***Imaging***.

Our projects can be applied to health outcomes including ***Diagnostics & clinical monitoring, Electroceuticals, Brain repair & neuroregeneration, Brain circuits in health & disease, Rehabilitation & augmentation***, and ***Lifelong health & well-being.***

Age-associated disease forms a strong focus in Centre research, with over 50% of projects in the Centre for Doctoral Training involving work on dementia, Alzheimer's or age-associated disease. However, Centre projects address a wide range of other disorders including ALS, cancer, cerebral palsy, CNS, epilepsy, hearing impairment, multiple sclerosis, neurotrauma, Parkinson's, psychiatric disorders, sleep disorders and stroke.

The Centre for Neurotechnology has formed a key part of the case for £20M of funding provided to the new Michael Uren Biomedical Engineering Research Hub at White City (UKRPIF).

RESEARCH FUNDING

The Centre for Neurotechnology has leveraged over £300K in CDTN studentships from external partners up to 2016. Grants awarded to Centre members in 2016 include:

- **Action Medical Research**: *Network dysfunction after paediatric traumatic brain injury* (2016-2019), SHARP, David J
- **Biotechnology and Biological Sciences Research Council** (BBSRC): *How do auditory cortical neurons represent ethologically relevant natural stimuli? Characterizing stimulus feature selectivity and invariance.* (2016-2019), KOZLOV, Andriy
- **Biotechnology and Biological Sciences Research Council** (BBSRC): *Plasticity of inhibitory synaptic transmission in the hippocampus* (2016-2019), CLOPATH, Claudia
- **Biotechnology and Biological Sciences Research Council** (BBSRC): *Relating changes in synaptic function to cognitive decline during normal healthy ageing* (2016-2019), BRICKLEY, Stephen G, CHADDERTON, Paul T, WISDEN, Bill
- **Commission of the European Communities** (CEC): *Applying voltage-imaging techniques to visualise the effect of lysergic acid diethylamide (LSD) on cortical layer V pyramidal cells and its adaptation during tolerance development* - H2020 MSCA IF (2016-2018), KNOPFEL, Thomas
- **Commission of the European Communities** (CEC): *Neurophysiological Biomarkers of Cortical Plasticity Induced by Neuromodulation* - NeuroN - H2020 MSCA IF (2016-2017), FARINA, Dario
- **Commission of the European Communities** (CEC): *POC One-EG Wearable Brain Monitoring Technology for Quick Diagnosis of Sleep Disorders* - H2020 ERC (2016-2017), RODRIGUEZ VILLEGAS, Esther
- **Engineering & Physical Science Research Council** (EPSRC): *Aquatic Micro Aerial Vehicle (Aqua MAV): Bio-inspired air-water mobility for robotics* (2016-2016), KOVAC, Mirko
- **Engineering & Physical Science Research Council** (EPSRC): *Closed-Loop Multisensory Brain-Computer Interface for Enhanced Decision Accuracy* (2016-2019), MANDIC, Danilo
- **Engineering & Physical Science Research Council** (EPSRC): *MOTION - morphological computation of perception and action* (2016-2019), BURDET, Etienne
- **Imperial College Healthcare NHS Trust**- BRC Funding: *CDKL5 in the processing of pain: a novel role for a poorly characterized symptom in CDKL5 syndrome* - BRC Funding 2016-2017 (Brain Sciences) (2016-2017), DI GIOVANNI, Simone
- **Imperial College Healthcare NHS Trust**- BRC Funding: *Imidazoline positron emission tomography using BU99008 to investigate astrocytic response after traumatic brain injury* (2016-2017), SHARP, David J
- **Imperial Innovations Ltd**: *Wearable TBI monitor-Spike Sight* (2016-2017), BOUTELLE, Martyn G
- **Medical Research Council** (MRC): *CRACK IT Challenge 2: "A Miniature wireless EEG system for continuous monitoring of mice brainwave activity"* (2016-2017), RODRIGUEZ VILLEGAS, Esther
- **Medical Research Council** (MRC): *DPUK Imaging Informatics* (MRC DPUK Programme) (2016-2016), MATTHEWS, Paul M
- **Medical Research Council** (MRC): *MRC Dementias Platforms UK Imaging Network Partnership Grant* (2016-2019), MATTHEWS, Paul M
- **Medical Research Council** (MRC): *Pathfinder: An experimental medicine study of the 18 kD translocator protein as a novel neuroimmunodulatory target for multiple sclerosis* (2016-2019), MATTHEWS, Paul M
- **Medical Research Council** (MRC): *The role of 18kDA Translocator Protein (TSPO) in cellular bioenergetics and microglial activation* (David Owen) (2016-2020), MATTHEWS, Paul M

RESEARCH

- **Medical Research Council** (MRC): *The Role of Neural Activity in Enhancing Axon and Presynaptic Regeneration in the Adult Injured Neocortex In Vivo* (2016-2019), DE PAOLA, Vincenzo
- **National Institute for Health Research** (NIHR) *ITMAT: Probing functional network dynamics during intentional learning in early stage Parkinson's disease* (2016), HAMPSHIRE, Adam
- **National Institute for Health Research** (NIHR): *NIHR Remote tracking and training of cognition to assist management of long-term outcomes in traumatic brain injury patients* (2016-2020), HAMPSHIRE, Adam
- **National Institute for Health Research** (NIHR): *NIHR Remote tracking and training of cognition to assist management of long-term outcomes in traumatic brain injury patients* (2016-2020), SHARP, David J
- **National Institutes of Health** (NIH): *Near Infrared Genetically Encoded Voltage Indicators (NIR-GEVIs) for All Optical Electrophysiology* (AOE) (2016-2019), KNOPFEL, Thomas
- **National Multiple Sclerosis Society**: *The role of meningeal inflammation-induced cytokine signalling and mitochondrial dysfunction in neurodegeneration in progressive MS* (2016-2019), REYNOLDS, Richard
- **Nokia Technologies Oy**: *Data-Driven Sleep Neurotechnology for Nokia* (2016-2017), FAISAL, Aldo
- **Royal Academy Of Engineering**: *Holographic Light Shaping for Reverse Engineering Neural Circuit Learning* (2016-2020), Fellowship to FOUST, Amanda J
- **The Leverhulme Trust**: *Probing synaptic amyloid-beta aggregation by redox reaction enabled super-resolution imaging* (2016-2019), KNOPFEL, Thomas
- **The Leverhulme Trust**: *Receptive field development through synaptic plasticity* (2016-2017), CLOPATH, Claudia
- **The Royal Society**: *Long Range Specific Connectivity in a computer simulation of large scale neural networks* (2016-2017), CLOPATH, Claudia
- **Wellcome Trust**: *Feasibility demonstration of temporal interference stimulation for non-invasive deep brain stimulation therapy* (2016-2018), GROSSMAN, Nir
- **Wellcome Trust**: *Holographic Induction of Neural Circuit Plasticity* (2016-2018), FOUST, Amanda J
- **Wellcome Trust**: *Memory across multiple timescales* (2016-2023), CLOPATH, Claudia
- **Wellcome Trust**: *Multi-timescale processing of speech through cortical oscillations in health and in aphasic stroke* (2016-2018), REICHENBACH, Johann D T
- **Wings for Life Spinal Cord Research Foundation**: *Modulation of AMPK as a candidate novel regenerative pathway after spinal cord injury* (2016-2018), DI GIOVANNI, Simone

RESEARCH OUTPUTS

PUBLICATIONS AND PATENTS

JOURNAL ARTICLES

- Kirkpatrick J, Pascanu R, Rabinowitz N, Veness J, Desjardins G, Rusu AA, Milan K, Quan J, Ramalho T, Grabska-Barwinska A, Hassabis D, Clopath C, Kumaran D, Hadsell Ret al., *Overcoming catastrophic forgetting in neural networks*, Proceedings of the National Academy of Sciences of the United States of America, ISSN: 1091-6490
- Makin T, de Vignemont F, Faisal AA, *Neurocognitive considerations to the embodiment of technology*, Nature Biomedical Engineering, ISSN: 2157-846X
- Antic SD, Empson RM, Knoepfel T, 2016, *Voltage imaging to understand connections and functions of neuronal circuits*, Journal of Neurophysiology, Vol: 116, Pages: 135-152, ISSN: 0022-3077
- Aszmann OC, Vujaklija I, Roche AD, Salminger S, Herceg M, Sturma A, Hruby LA, Pittermann A, Hofer C, Amsuess S, Farina Det al., 2016, *Elective amputation and bionic substitution restore functional hand use after critical soft tissue injuries*, Scientific Reports, Vol: 6, ISSN: 2045-2322
- Badura A, Clopath C, Schonewille M, De Zeeuw CIet al., 2016, *Modeled changes of cerebellar activity in mutant mice are predictive of their learning impairments*, Scientific Reports, Vol: 6, ISSN: 2045-2322
- Berditchevskaia A, Caze RD, Schultz SR, 2016, *Performance in a GO/NOGO perceptual task reflects a balance between impulsive and instrumental components of behaviour*, Scientific Reports, Vol: 6, ISSN: 2045-2322
- Braga RM, Fu RZ, Seemungal BM, Wise RJS, Leech Ret al., 2016, *Eye Movements during Auditory Attention Predict Individual Differences in Dorsal Attention Network Activity*, Frontiers in Human Neuroscience, Vol: 10, ISSN: 1662-5161
- Chen S, Augustine GJ, Chadderton P, 2016, *The cerebellum linearly encodes whisker position during voluntary movement*, eLIFE, Vol: 5, ISSN: 2050-084X
- De Marcellis A, Palange E, Nubile L, Faccio M, Stanchieri GDP, Constandinou TGet al., 2016, *A Pulsed Coding Technique Based on Optical UWB Modulation for High Data Rate Low Power Wireless Implantable Biotelemetry*, Electronics, Vol: 5, ISSN: 2079-9292
- Evans BD, Jarvis S, Schultz SR, Nikolic Ket al., 2016, *PyRhO: A Multiscale Optogenetics Simulation Platform*, Frontiers in Neuroinformatics, Vol: 10, ISSN: 1662-5196
- Fagerholm ED, Scott G, Shew WL, Song C, Leech R, Knopfel T, Sharp DJet al., 2016, *Cortical Entropy, Mutual Information and Scale-Free Dynamics in Waking Mice*, Cerebral Cortex, Vol: 26, Pages: 3945-3952, ISSN: 1047-3211
- Guven O, Eftekhar A, Kindt W, Constandinou TGet al., 2016, *Computationally efficient real-time interpolation algorithm for non-uniform sampled biosignals*, Healthcare Technology Letters, Vol: 3, Pages: 105-110, ISSN: 2053-3713
- Hahne JM, Farina D, Jiang N, Liebetanz Det al., 2016, *A novel percutaneous electrode implant for improving robustness in advanced myoelectric control*, Frontiers in Neuroscience, Vol: 10, ISSN: 1662-4548
- Hammad SH, Kamavuako EN, Farina D, Jensen Wet al., 2016, *Simulation of a Real-Time Brain Computer Interface for Detecting a Self-Paced Hitting Task*, Neuromodulation, Vol: 19, Pages: 804-811
- Hemakom A, Goverdovsky V, Looney D, Mandic DPet al., 2016, *Adaptive-projection intrinsically transformed multivariate empirical mode decomposition in cooperative brain-computer interface applications*, Philosophical Transactions of the Royal Society A-Mathematical Physical And Engineering Sciences, Vol: 374, ISSN: 1364-503X
- Imtiaz SA, Mardell J, Saremi-Yarahmadi S, Rodriguez-Villegas Eet al., 2016, *ECG artefact identification and removal in mHealth systems for continuous patient monitoring*, Healthcare Technology Letters, Vol: 3, Pages: 171-176, ISSN: 2053-3713
- Jager P, Ye Z, Yu X, Zagoraiou L, Prekop H-T, Partanen J, Jessell TM, Wisden W, Brickley SG, Delogu Aet al., 2016, *Tectal-derived interneurons contribute to phasic and tonic inhibition in the visual thalamus*, Nature Communications,

Vol: 7, ISSN: 2041-1723

- Kim Y, Warren SC, Stone JM, Knight JC, Neil MAA, Paterson C, Dunsby CW, French PMWet al., 2016, *Adaptive Multiphoton Endomicroscope Incorporating a Polarization-Maintaining Multicore Optical Fibre*, IEEE Journal of Selected Topics in Quantum Electronics, Vol: 22, ISSN: 1077-260X
- Kovac M, 2016, ROBOTICS. *Learning from nature how to land aerial robots*, Science, Vol: 352, Pages: 895-896
- Kozlov AS, Gentner TQ, 2016, *Central auditory neurons have composite receptive fields*, Proceedings of the National Academy of Sciences of the United States of America, Vol: 113, Pages: 1441-1446, ISSN: 0027-8424
- Leppa E, Linden A-M, Aller MI, Wulff P, Vekovischeva O, Luscher B, Lueddens H, Wisden W, Korpi ERet al., 2016, *Increased Motor-Impairing Effects of the Neuroactive Steroid Pregnanolone in Mice with Targeted Inactivation of the GABA(A) Receptor gamma 2 Subunit in the Cerebellum*, Frontiers in Pharmacology, Vol: 7, ISSN: 1663-9812
- Looney D, Goverdovsky V, Rosenzweig I, Morrell MJ, Mandic DPet al., 2016, *Wearable In-Ear Encephalography Sensor for Monitoring Sleep Preliminary Observations from Nap Studies*, Annals of the American Thoracic Society, Vol: 13, Pages: 2229-2233, ISSN: 1546-3222
- Li Z, Yang C, Burdet E, 2016, *An Overview of Biomedical Robotics and Bio-Mechatronics Systems and Applications*, IEEE Transactions on Systems Man Cybernetics-Systems, Vol: 46, Pages: 869-874, ISSN: 2168-2216
- Lin C, Wang B-H, Jiang N, Xu R, Mrachacz-Kersting N, Farina Det al., 2016, *Discriminative Manifold Learning Based Detection of Movement-Related Cortical Potentials*, IEEE Trans Neural Syst Rehabil Eng, Vol: 24, Pages: 921-927
- Lorenz R, Monti RP, Violante IR, Anagnostopoulos C, Faisal AA, Montana G, Leech Ret al., 2016, *The Automatic Neuroscientist: A framework for optimizing experimental design with closed-loop real-time fMRI*, NEUROIMAGE, Vol: 129, Pages: 320-334, ISSN: 1053-8119
- Matthews PM, Hampshire A, 2016, *Clinical Concepts Emerging from fMRI Functional Connectomics*, NEURON, Vol: 91, Pages: 511-528, ISSN: 0896-6273
- Matthews PM, Roncaroli F, Waldman A, Sormani MP, De Stefano N, Giovannoni G, Reynolds Ret al., 2016, *A practical review of the neuropathology and neuroimaging of multiple sclerosis*, Pract Neurol, Vol: 16, Pages: 279-287
- Miller KL, Alfaro-Almagro F, Bangerter NK, Thomas DL, Yacoub E, Xu J, Bartsch AJ, Jbabdi S, Sotiropoulos SN, Andersson JLR, Griffanti L, Douaud G, Okell TW, Weale P, Dragonu J, Garratt S, Hudson S, Collins R, Jenkinson M, Matthews PM, Smith SMet al., 2016, *Multimodal population brain imaging in the UK Biobank prospective epidemiological study*, Nature Neuroscience, Vol: 19, Pages: 1523-1536, ISSN: 1097-6256
- Mrachacz-Kersting N, Jiang N, Stevenson AJT, Niazi IK, Kostic V, Pavlovic A, Radovanovic S, Djuric-Jovicic M, Agosta F, Dremstrup K, Farina Det al., 2016, *Efficient neuroplasticity induction in chronic stroke patients by an associative brain-computer interface*, J Neurophysiol, Vol: 115, Pages: 1410-1421
- Negro F, Muceli S, Castronovo AM, Holobar A, Farina Det al., 2016, *Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation*, J Neural Eng, Vol: 13
- Nicolaou N, Constandinou TG, 2016, *A Nonlinear Causality Estimator Based on Non-Parametric Multiplicative Regression*, Frontiers in Neuroinformatics, Vol: 10, ISSN: 1662-5196
- Papadimitriou KI, Wang C, Rogers ML, Gowers SAN, Leong CL, Boutelle MG, Drakakis EMet al., 2016, *High-Performance Bioinstrumentation for Real-Time Neuroelectrochemical Traumatic Brain Injury Monitoring*, Frontiers in Human Neuroscience, Vol: 10, ISSN: 1662-5161
- Patel GK, Dosen S, Castellini C, Farina Det al., 2016, *Multichannel electrotactile feedback for simultaneous and proportional myoelectric control*, Journal of Neural Engineering, Vol: 13, ISSN: 1741-2560
- Pedrosa V, Clopath C, 2016, *The Role of Neuromodulators in Cortical Plasticity. A Computational Perspective*, Front Synaptic Neurosci, Vol: 8, ISSN: 1663-3563
- Reichenbach CS, Braiman C, Schiff ND, Hudspeth AJ, Reichenbach Tet al., 2016, *The Auditory-Brainstem Response*

to Continuous, Non-repetitive Speech Is Modulated by the Speech Envelope and Reflects Speech Processing, Frontiers in Computational Neuroscience, Vol: 10, ISSN: 1662-5188

- Reinkensmeyer DJ, Burdet E, Casadio M, Krakauer JW, Kwakkel G, Lang CE, Swinnen SP, Ward NS, Schweighofer Net al., 2016, *Computational neurorehabilitation: modeling plasticity and learning to predict recovery*, Journal of Neuroengineering and Rehabilitation, Vol: 13, ISSN: 1743-0003
- Riillo F, Bagnato C, Allievi AG, Takagi A, Fabrizi L, Saggio G, Arichi T, Burdet Eet al., 2016, *A Simple fMRI Compatible Robotic Stimulator to Study the Neural Mechanisms of Touch and Pain*, Annals of Biomedical Engineering, Vol: 44, Pages: 2431-2441, ISSN: 0090-6964
- Rinne P, Mace M, Nakornchai T, Zimmerman K, Fayer S, Sharma P, Liardon J-L, Burdet E, Bentley Pet al., 2016, *Democratizing Neurorehabilitation: How Accessible are Low-Cost Mobile-Gaming Technologies for Self-Rehabilitation of Arm Disability in Stroke?*, PLoS One, Vol: 11, ISSN: 1932-6203
- Rivera-Rubio J, Arulkumaran K, Rishi H, Alexiou I, Bharath AAet al., 2016, *An assistive haptic interface for appearance-based indoor navigation*, Computer Vision and Image Understanding, Vol: 149, Pages: 126-145, ISSN: 1077-3142
- Rossant C, Kadir SN, Goodman DFM, Schulman J, Hunter MLD, Saleem AB, Grosmark A, Belluscio M, Denfield GH, Ecker AS, Tolias AS, Solomon S, Buzsaki G, Carandini M, Harris KDet al., 2016, *Spike sorting for large, dense electrode arrays*, Nature Neuroscience, Vol: 19, Pages: 634-+, ISSN: 1097-6256
- Sartori M, Llyod DG, Farina D, 2016, *Neural Data-Driven Musculoskeletal Modeling for Personalized Neurorehabilitation Technologies*, IEEE Trans Biomed Eng, Vol: 63, Pages: 879-893
- Schweisfurth MA, Markovic M, Dosen S, Teich F, Graimann B, Farina Det al., 2016, *Electrotactile EMG feedback improves the control of prosthesis grasping force*, Journal of Neural Engineering, Vol: 13, ISSN: 1741-2560
- Schultz SR, Copeland C, Foust A, Quicke P and Schuck R, 2016, *Advances in two photon scanning and scanless microscopic technologies for imaging neural circuits*. Proceedings of the IEEE, 105(1):139-157, doi: 10.1109/JPROC.2016.2577380.
- Scott G, Ramlackhansingh AF, Edison P, Hellyer P, Cole J, Veronese M, Leech R, Greenwood RJ, Turkheimer FE, Gentleman SM, Heckemann RA, Matthews PM, Brooks DJ, Sharp DJet al., 2016, *Amyloid pathology and axonal injury after brain trauma*, Neurology, Vol: 86, Pages: 821-828, ISSN: 0028-3878
- Sollini J, Chadderton P, 2016, *Comodulation Enhances Signal Detection via Priming of Auditory Cortical Circuits*, Journal of Neuroscience, Vol: 36, Pages: 12299-12311, ISSN: 0270-6474

- Stango A, Yazdandoost KY, Negro F, Farina Det al., 2016, *Characterization of In-Body to On-Body Wireless Radio Frequency Link for Upper Limb Prostheses*., PLoS One, Vol: 11
- Tang J, Jimenez SCA, Chakraborty S, Schultz SRet al., 2016, *Visual Receptive Field Properties of Neurons in the Mouse Lateral Geniculate Nucleus*, PLoS One, Vol: 11, ISSN: 1932-6203
- Torricelli D, Gonzalez J, Weckx M, Jiménez-Fabián R, Vanderborght B, Sartori M, Dosen S, Farina D, Lefeber D, Pons JLet al., 2016, *Human-like compliant locomotion: State of the art of robotic implementations*, Bioinspiration and Biomimetics, Vol: 11, ISSN: 1748-3182
- Uygun DS, Ye Z, Zecharia AY, Harding EC, Yu X, Yustos R, Vyssotski AL, Brickley SG, Franks NP, Wisden Wet al., 2016, *Bottom-Up versus Top-Down Induction of Sleep by Zolpidem Acting on Histaminergic and Neocortex Neurons,* Journal of Neuroscience, Vol: 36, Pages: 11171-11184, ISSN: 0270-6474
- Warren RL, Ramamoorthy S, Ciganovic N, Zhang Y, Wilson TM, Petrie T, Wang RK, Jacques SL, Reichenbach T, Nuttall AL, Fridberger Aet al., 2016, *Minimal basilar membrane motion in low-frequency hearing*, Proceedings of the National Academy of Sciences of the United States of America, Vol: 113, Pages: E4304-E4310, ISSN: 0027-8424
- Warren SC, Kim Y, Stone JM, Mitchell C, Knight JC, Neil MAA, Paterson C, French PMW, Dunsby Cet al., 2016, *Adaptive multiphoton endomicroscopy through a dynamically deformed multicore optical fiber using proximal detection*, Optics Express, Vol: 24, Pages: 21474-21484, ISSN: 1094-4087
- Wilson C, Munoz-Palma E, Henriquez DR, Palmisano I, Tulio Nunez M, Di Giovanni S, Gonzalez-Billault Cet al., 2016, *A Feed-Forward Mechanism Involving the NOX Complex and RyR-Mediated Ca2+ Release During Axonal Specification*, Journal of Neuroscience, Vol: 36, Pages: 11107-11119, ISSN: 0270-6474
- Xu R, Jiang N, Dosen S, Lin C, Mrachacz-Kersting N, Dremstrup K, Farina Det al., 2016, *Endogenous Sensory Discrimination and Selection by a Fast Brain Switch for a High Transfer Rate Brain-Computer Interface*, IEEE Trans Neural Syst Rehabil Eng, Vol: 24, Pages: 901-910
- Yousif N, Bhatt H, Bain PG, Nandi D, Seemungal BMet al., 2016, *The effect of pedunculopontine nucleus deep brain stimulation on postural sway and vestibular perception*, European Journal of Neurology, Vol: 23, Pages: 668-670, ISSN: 1351-5101
- Yousif N, Fu RZ, Bourquin BA-E-E, Bhrugubanda V, Schultz SR, Seemungal BMet al., 2016, *Dopamine Activation Preserves Visual Motion Perception Despite Noise Interference of Human V5/MT*, Journal of Neuroscience, Vol: 36, Pages: 9303-9312, ISSN: 0270-6474
- Štrbac M, Belić M, Isaković M, Kojić V, Bijelić G, Popović I, Radotić M, Došen S, Marković M, Farina D, Keller Tet al., 2016, *Integrated and flexible multichannel interface for electrotactile stimulation*, Journal of Neural Engineering, Vol: 13, ISSN: 1741-2560

CONFERENCE PAPERS

- Angeles P, Mace M, Admiraal M, Burdet E, Pavese N, Vaidyanathan Ret al., 2016, *A Wearable Automated System to Quantify Parkinsonian Symptoms Enabling Closed Loop Deep Brain Stimulation*, 17th Annual Conference on Towards Autonomous Robotic Systems (TAROS), Publisher: Springer Int Publishing AG, Pages: 8-19, ISSN: 0302-9743
- Arulkumaran K, Dilokthanakul N, Shanahan M, Bharath AAet al., 2016, *Classifying Options for Deep Reinforcement Learning*, IJCAI 2016 Workshop on Deep Reinforcement Learning.
- Barsakcioglu DY, Constandinou TG, 2016, *A 32-Channel MCU-based Feature Extraction and Classification for Scalable On-node Spike Sorting*, IEEE International Symposium on Circuits and Systems (ISCAS), Publisher: IEEE, Pages: 1310-1313, ISSN: 0271-4302
- Bevan R, Griffiths L, Watkins L, Evans R, McInerney B, Rees M, Calabrese M, Magliozzi R, Reynolds R, Allen I, Fitzgerald

D, Howell Oet al., 2016, *Significant meningeal inflammation and cortical neurodegeneration in a post-mortem cohort of short disease duration multiple sclerosis*, 32nd Congress of the European-Committee-for-Treatment-and-Research-in-Multiple-Sclerosis (ECTRIMS), Publisher: Sage Publications Ltd, Pages: 468-468, ISSN: 1352-4585

- Boltersdorf T, Gavins F, Long N, 2016, *Designing Novel Imaging Probes for Targeting Inflammatory Lesions in Brain Disorders.* Invited Speaker Abstract Booklet. New York: 6th annual meeting of The International Society for Neurovascular Disease (ISNVD) 2016. Online.
- De Marcellis A, Palange E, Faccio M, Nubile L, Stanchieri GDP, Petrucci S, Constandinou Tet al., 2016, *A New Optical UWB Modulation Technique for 250Mbps Wireless Link in Implantable Biotelemetry Systems*, 30th Eurosensors Conference, Publisher: Elsevier Science BV, Pages: 1676-1680, ISSN: 1877-7058
- Elia M, Leene LB, Constandinou TG, 2016, *Continuous-Time Micropower Interface for Neural Recording Applications,* IEEE International Symposium on Circuits and Systems (ISCAS), Publisher: IEEE, Pages: 534-537, ISSN: 0271-4302
- Frehlick Z, Williams I, Constandinou TG, 2016, *Improving Neural Spike Sorting Performance using Template Enhancement*, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 524-527, ISSN: 2163-4025
- Hassan S, Nightingale AM, Leong CL, Zhang Y, Evans G, Boutelle MG, Niu XZet al., 2016, *Wearable droplet-based microfluidic sensor device for continuous sampling and real-time analysis*, 20th International Conference on Miniaturized Systems for Chemistry and Life Sciences. Pages: 43-44
- Huang JV, Wang Y, Krapp HG, 2016, *Wall Following in a Semi-closed-loop Fly-Robotic Interface*, 5th International Conference on Biomimetic and Biohybrid Systems (Living Machines), Publisher: Springer Int Publishing AG, Pages: 85-96, ISSN: 0302-9743
- Jameel ASMM, Mace M, Wang S, Vaidyanathan R, Al Mamun KAet al., 2016, *Predicting Movement and Laterality From Deep Brain Local Field Potentials*, 1st International Conference on Medical Engineering, Health Informatics and Technology (MediTec), Publisher: IEEE
- Jeanneret M, Bagnato C, Allievi AG, Burdet Eet al., 2016, *A Versatile Robotic Haptic Stimulator to Study the Influence of Pain on Human Motor Control and Learning*, 10th International Conference on Haptics - Perception, Devices, Control, and Applications (EuroHaptics), Publisher: Springer Int Publishing AG, Pages: 101-110, ISSN: 0302-9743
- Lauteslager T, Tommer M, Kjelgard KG, Lande TS, Constandinou TGet al., 2016, *Intracranial Heart Rate Detection*

Using UWB Radar, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 119-122, ISSN: 2163-4025

- Leene LB, Constandinou TG, 2016, *A 2.7 mu W/MIPS, 0.88GOPS/mm(2) Distributed Processor for Implantable Brain Machine Interfaces*, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 360-363, ISSN: 2163-4025
- Li L, Violante I, Ross E, Leech R, Hampshire A, Carmichael D, Sharp Det al., 2016, *Brain Network Modulation with Non-Invasive Brain Stimulation*, Annual Meeting of the Association-of-British-Neurologists (ABN), Publisher: BMJ Publishing Group, ISSN: 0022-3050
- Liu Y, Pereira JL, Constandinou TG, 2016, *Clockless Continuous-Time Neural Spike Sorting: Method, Implementation and Evaluation*, IEEE International Symposium on Circuits and Systems (ISCAS), Publisher: IEEE, Pages: 538-541, ISSN: 0271-4302
- Lorenz R, Monti RP, Hampshire A, Koush Y, Anagnostopoulos C, Faisal AA, Sharp D, Montana G, Leech R, Violante IRet al., 2016, *Towards tailoring non-invasive brain stimulation using real-time fMRI and Bayesian optimization, 6th International Workshop on Pattern Recognition in Neuroimaging (PRNI)*, Publisher: IEEE, Pages: 49-52, ISSN: 2330-9989
- Luan S, Liu Y, Williams I, Constandinou TGet al., 2016, *An Event-Driven SoC for Neural Recording*, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 404-407, ISSN: 2163-4025
- Luan S, Williams I, de Carvalho F, Jackson A, Quian Quiroga R, Constandinou TGet al., 2016, *Next Generation Neural Interfaces for low-power multichannel spike sorting*, FENS Forum of Neuroscience, Publisher: FENS
- Lubba C, Le Guen Y, Jarvis S, Jones N and Schultz SR, 2016, *PyPN - a tool for simulating peripheral nerves*. Program No. 368.24. 2016 Abstract Viewer/Itinerary Planner. San Diego: Society for Neuroscience. Online.
- Lubba C, Le Guen Y, Jarvis S, Jones N and Schultz SR, 2016, *PyPN – A Python Simulator of Peripheral Nerves*. Program No. 16. 2016 Poster Session Abstract Booklet. New York: 13th Key Symposium 2016 Bioelectronic Medicine — Technology Targeting Molecular Mechanisms. Online.
- Nicolaou N, Constandinou TG, 2016, *Phase-Amplitude Coupling during propofol-induced sedation: an exploratory approach*, FENS Forum of Neuroscience, Publisher: FENS
- Patrick KCA, Imtiaz SA, Bowyer S, Rodriguez-Villegas Eet al., 2016, *An Algorithm for Automatic Detection of Drowsiness for Use in Wearable EEG Systems*, 38th Annual International Conference of the IEEE-Engineering-in-Medicine-and-Biology-Society (EMBC), Publisher: IEEE, Pages: 3523-3526, ISSN: 1557-170X
- Peress L, Violante IR, Scott G, Zimmerman K, Sharp D, Nicholas R, Raffel Jet al., 2016, *Thalamic magnetic resonance spectroscopy in highly active multiple sclerosis*, 32nd Congress of the European-Committee-for-Treatment-and-Research-in-Multiple-Sclerosis (ECTRIMS), Publisher: Sage Publications Ltd, Pages: 210-211, ISSN: 1352-4585
- Ramezani R, Dehkhoda F, Soltan A, Degenaar P, Liu Y, Constandinou Tet al., 2016, *An Optrode with built-in self-diagnostic and fracture sensor for cortical brain stimulation*, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 392-395, ISSN: 2163-4025
- Reynolds S, Copeland CS, Schultz SR, Dragotti PLet al., 2016, *An Extension of the FRI Framework for Calcium Transient Detection*, IEEE 13th International Symposium on Biomedical Imaging (ISBI), Publisher: IEEE, Pages: 676-679, ISSN: 1945-7928
- Tostado PM, Abbott WW, Faisal AA, 2016, *3D gaze cursor: continuous calibration and end-point grasp control of robotic actuators*, IEEE International Conference on Robotics and Automation (ICRA), Publisher: IEEE, Pages: 3295-3300, ISSN: 1050-4729
- Troiani F, Nikolic K, Constandinou TG, 2016, *Optical coherence tomography for detection of compound action potential in Xenopus Laevis sciatic nerve*, Conference on Clinical and Translational Neurophotonics; Neural Imaging and

Sensing; and Optogenetics and Optical Manipulation, Publisher: SPIE-Int Soc Optical Engineering, ISSN: 0277-786X

- Wilhelm E, Mace M, Takagi A, Farkhatdinov I, Guy S, Burdet Eet al., 2016, *Investigating Tactile Sensation in the Hand Using a Robot-Based Tactile Assessment Tool*, 10th International Conference on Haptics - Perception, Devices, Control, and Applications (EuroHaptics), Publisher: Springer Int Publishing AG, Pages: 17-24, ISSN: 0302-9743
- Williams I, Rapeaux A, Liu Y, Luan S, Constandinou TGet al., 2016, *A 32-Ch. Bidirectional Neural/EMG Interface with on-Chip Spike Detection for Sensorimotor Feedback*, 12th IEEE Biomedical Circuits and Systems Conference (BioCAS), Publisher: IEEE, Pages: 528-531, ISSN: 2163-4025

BOOKS/BOOK CHAPTERS

- Merletti R, Farina D, 2016, *Surface Electromyography: Physiology, Engineering and Applications*, ISBN: 9781119082934
- Faisal AA, Neishabouri A, 2016, *Fundamental Constraints on the Evolution of Neurons*, The Wiley-Blackwell Handbook of Evolutionary Neuroscience, Pages: 153-172, ISBN: 9781118316757
- Fernández-Dueñas V, Morató X, Knöpfel T, Ciruela Fet al., 2016, *Dynamic recording of membrane potential from hippocampal neurons by using a FRET-based voltage biosensor*, Neuromethods, Pages: 447-454
- Lourenco PR, Abbott WW, Faisal AA, 2016, *Supervised EEG Ocular Artefact Correction Through Eye-Tracking*, Editors: Londral, Encarnacao, Publisher: Springer Int Publishing AG, Pages: 99-113, ISBN: 978-3-319-26240-6
- Rodriguez M, Sylaidi A, Faisal AA, 2016, *An fMRI-Compatible System for 3DOF Motion Tracking of Objects* in Haptic Motor Control Studies, Editors: Londral, Encarnacao, Publisher: Springer Int Publishing AG, Pages: 115-123, ISBN: 978-3-319-26240-6

SOFTWARE

- Goodman DFM, Stimberg M, Brette R, 2016, *Brian 2.0 simulator*.

PATENTS

- T. G. Constandinou and A. Jackson, "*Implantable neural interface*," GB Patent (application) 1608958.3, May 2016

INVITED TALKS

- February 2016: *Wearable technologies for remote diagnosis of respiratory conditions*. Sensors in Medicine Conference, London (Rodriguez Villegas)
- February 2016: *Spatial pattern codes for sensory information: a tale of two cortices*. National University of Singapore (Schultz)
- February 2016: *Vestibular cognition: its components and clinical application*. Neurology Departmental talk - Addenbrooke's Hospital., Cambridge (Seemungal)
- March 2016: *Haptic interfaces for neuroscience investigations.* Department of Microengineering, EPFL (Burdet)
- March 2016: *Acupebble: A new wearable technology for self-diagnosis of respiratory problems*. Launch Festival, San Francisco (Rodriguez Villegas)
- March 2016: *Low Power Electronics in Wearable Technologies*. Huawei (Rodriguez Villegas)

RESEARCH

- April 2016: *The Promise of Optogenetics for Neuroscience Drug Discovery*. Eli Lilly Centre for Cognitive Neuroscience (CCN), Windlesham, (Knopfel)
- May 2016: *Sensorimotor interaction between humans.* Japan-Europe international meeting on Embodied-Brain: Perspectives from Motor Control and Muscle Synergies, Taormina Sicily, Italy (Burdet)
- May 2016: *Collaborative Robots for Mobility Assistance and Rehabilitation.* Tutorial on Medical robotics, , IEEE Int Conf on Robotics and Automation (ICRA) (Burdet)
- May 2016: *Optogenetic tool for mesosopic-level imaging approaches: Bridging cellular level and systems physiology*. Institut fur Neuroinformatik, Universitat Bochum, Germany (Knopfel)
- June 2016: *Interaction control: in humans, for robots.* School on Advanced Neurorehabilitation, Bayona, Spain (Burdet)
- June 2016: *Neural Interfaces & Microsystems: from State-of-the-Art to the Next Generation.* CNRS Workshop on Bioelectronics, Paris (Constandinou)
- June 2016: *Manoeuvrability on the fly*, Inaugural lecture, Imperial College London (Krapp)
- June 2016: *Acute Vertigo for the Neurologist: Diagnosis to Treatment*. Queen's Medical Centre Neurology Department, Nottingham University Hospitals NHS Trust, Nottingham (Seemungal)
- August 2016: *Illuminating brain functions*. Summer School Neurophysiology - EPFL/ETH, Zermatt, Switzerland (Knopfel)
- August 2016: *Analysis of Information Encoding and Dynamics in Optically Recorded Cortical Circuits*. Queensland Brain Institute, Brisbane, Australia (Schultz)
- August 2016: *Analysis of Information Encoding and Dynamics in Optically Recorded Cortical Circuits*. Eccles Institute of Neuroscience, John Curtin School of Medical Research, Australian National University (Schultz)
- August 2016: *Analysis of Information Encoding and Dynamics in Optically Recorded Cortical Circuits*. Plenary talk, Australasian Winter Conference on Brain Research, Queenstown, NZ (Schultz)
- September 2016: *Optogenetic indicators and channels*. Plymouth Microelectrode Techniques Course, Plymouth (Knopfel)
- September 2016: *Cortical circuit dynamics illuminated with genetically encoded voltage indicators*. The Svedberg Seminar Series, Uppsala University, Sweden (Knopfel)
- September 2016: *Acupebble: a novel wearable technology for self-diagnosis of respiratory diseases*. 3Cs (Rodriguez

Villegas)

- September 2016: *Encoding of virtual reality locomotion kinematics in cerebellar neural activity*. Centre for Brain Research, University of Auckland (Schultz)
- September 2016: *Analysis of Information Encoding and Dynamics in Optically Recorded Cortical Circuits*. Auckland Photonics Workshop, University of Auckland (Schultz)
- September 2016: *Two photon imaging of neural circuit activity: an in vivo, in vitro and ex vivo tool for studying mouse models of dementia*. Janssen Pharmaceuticals, Belgium (Schultz)
- October 2016: *Encoding of locomotion kinematics in cerebellar neural activity*. MRC Brain Network Dynamics Unit, University of Oxford (Schultz)
- October 2016: *Analysis of Information Encoding and Dynamics in Optically Recorded Cortical Circuits*. University of York (Schultz)
- November 2016: *Insects, Drones and Innovation*, Open lecture, Imperial College London (Kovac, Krapp)
- November 2016: *Wearable technologies for remote diagnosis of respiratory related conditions*. Royal Society of Medicine, London (Rodriguez Villegas)
- November 2016: *Will Your Grandchildren Dream of Electric Sheep?* Jesus College, Oxford (Schultz)
- December 2016: *The Bionic Man*, Inaugural lecture, Imperial College London (Farina)

OUTREACH AND PUBLIC ENGAGEMENT

IMPERIAL FESTIVAL

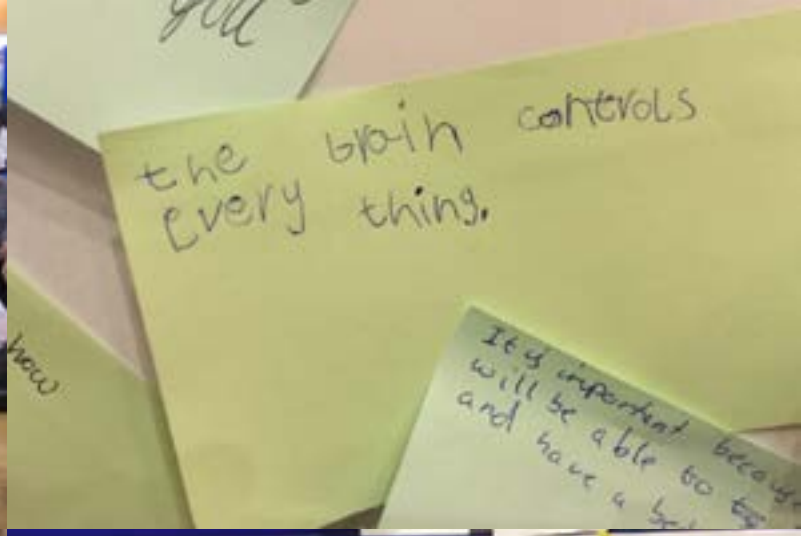
The annual Imperial Festival is a showcase of the best in science and arts at Imperial College. The event features interactive activities, performances and workshops and regularly attracts more than 15,000 public and alumni visitors. Members of the Centre participated in numerous activities at the 2016 festival and two interactive exhibits were run by students from the Centre for Doctoral Training in Neurotechnology for Life and Health. The "Brains of Brawn" exhibit explained how the brain and body controls muscles and allowed visitors to solve an interactive puzzle to make a muscle move. "Playing with Brainwaves" challenged visitors to control a specially designed computer game, using their "brainwaves" via an EEG headset. Visitors also had the opportunity to build a brain model, colour and make their own "brain-hat" depicting the parts of the brain and their functions, create pipe-cleaner neurons and even listen to the sound of their own muscles moving. The stands were highly successful and received hundreds of visitors over the weekend.

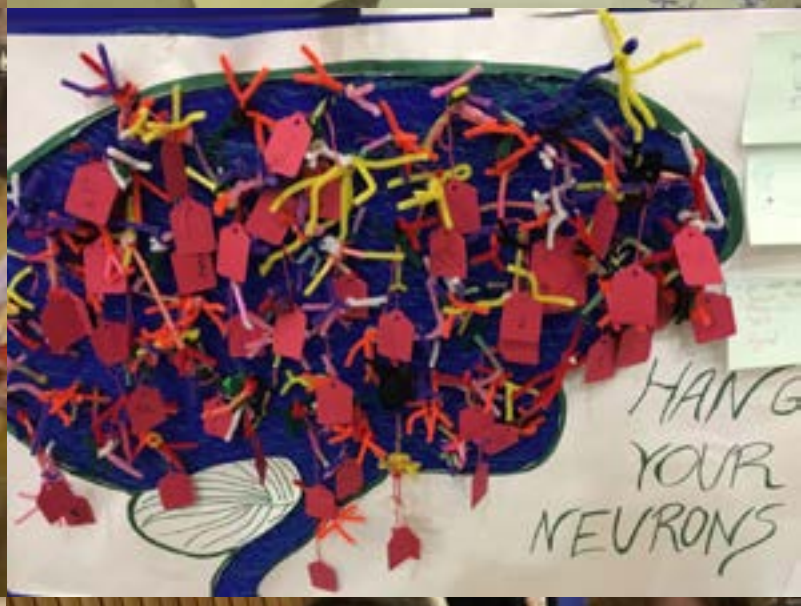
CDT FESTIVAL OF SCIENCE AND ENGINEERING

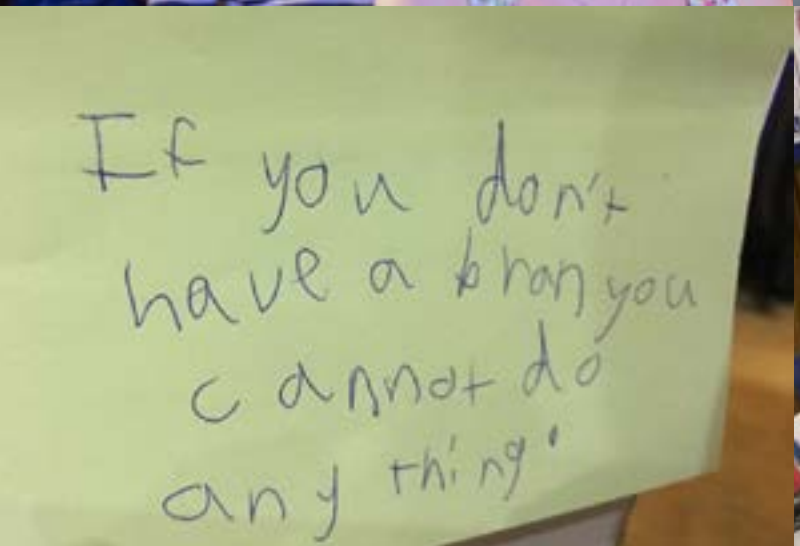
Imperial's fifth annual CDT Festival of Science took place on 15th April 2016 at Imperial College and focussed on the theme of "Science & Science-Fiction". The event, organised by the 14 CDTs at Imperial, invited speakers from academia and industry to share their perspectives on the interaction between science and science-fiction, and included a panel discussion on the subject of robotics and artificial intelligence. Festival activities included a virtual reality (VR) experience and the opportunity to manipulate an object in 3-D space with your mind using an EEG device, as well as a "Sci-Fi Shorts" competition.

CENTRE FOR NEUROTECHNOLOGY ANNUAL RESEARCH SYMPOSIUM

Imperial Neurotechnology, the Centre's second annual research symposium, was held on 20th July and brought together researchers from Imperial College and other national and international academic intuitions, industry colleagues and members of the public for a day of presentations and discussions on the subject of neurotechnology. External


the brain controls
Every thing.


HANG
YOUR
NEURONS


If you don't
have a brain you
cannot do
any thing.


Brains of Brawn

speakers included James Fawcett and Timothy O'Leary (Cambridge University), Wouter Serdijn (Delft University of Technology) and from industry, Nadia Malik (Eli Lilly & Co Ltd). Students from the CDTN cohort 2 presented posters showcasing their varied projects.

I'M AN ENGINEER, GET ME OUT OF HERE!

CDTN student James Clarke was a winner in November 2016 of the online outreach competition "I'm An Engineer, Get Me Out Of Here!". The competition is an online public engagement event that gets engineers talking to school students all over the UK. Engineers put up a profile on this site, answer students' questions about engineering, their work, the universe and beyond. They engage directly with students in live text-based chats. Students vote for their favourite engineer in an X-Factor style competition, to win £500 to spend on further public engagement. The event is divided into different themed zones with five engineers from that area. James was proclaimed the November winner in the "Diagnosis" zone.

OTHER ACTIVITIES

- Pint of Science (May 2016): public lecture (Vaidyanathan, Clarke)
- London Tech Week (June 2016): demonstration of biomechatronics research (Clarke, Caulcrick, Vaidyanathan)
- Green Man Festival (Aug 2016): demonstration of the sense of hearing, (Reichenbach)
- Sutton Trust Summer School (Aug 2016): Invited talk: *Microchips and Brain Implants* (Constandinou)
- New Scientist live (Sept/Oct 2016): demonstration of GripAble technology, human robotics and sensorimotor research (Burdet, Lotay, Dall'Orso)

MEDIA

- National Geographic (Feb 2016): contribution to Inner Ear Documentary (Reichenbach)
- New Atlas Magazine (Feb 2016): article on biomechatronics lab's sensor-connected sleeve for stroke rehabilitation (Vaidyanathan)
- National Geographic Radio (Mar 2016): podcast on hearing (Reichenbach)
- IEEE Spectrum (Jul 2016): article featuring in-ear EEG sensors (Mandic)
- The Sun, CBS News (Oct 2016): articles on GripAble and virtual physiotherapy (Bentley, Burdet, Lotay)
- BBC Click Live (Nov 2016): streamed broadcast attracting over 200K viewings including demostrations of research from the Biomechatronics lab (Clarke, Caulcrick, Vaidyanathan)
- BBC's "The One Show" (Nov 2016): feature on Deep Brain Stimulation research (Angeles, Vaidyanathan, Nandi)
- Financial Times (Dec 2016): article on big data mentioning Imperial collaboration with McLaren on using F1 sensor technology to detect neurological dysfunction

AWARDS

- 2016 NHS England Award for Innovation (gripAble (IC Human Robotics Group))
- Award for Best All-Round Presentation (April 2016), 6th annual meeting of The International Society for Neurovascular Disease 2016 in New York City (Boltersdorf)
- IET award for Most Promising Innovation in Robotics (July 2016), 17th Annual Conference on Towards Autonomous Robotic Systems (TAROS) 2016, Sheffield, UK (Angeles)
- 2016 Imperial College President's Award for Excellence in Research Supervision (Constandinou)
- Best Paper Award for "Intracranial Heart Rate Detection Using UWB Radar" by T Lautestlager, M Tommer, KG Kjelgardz, TS Lande, TG Constandinou (Oct 2016)

1

RESEARCH CASE STUDY

INDUSTRIAL COLLABORATION

MCLAREN APPLIED TECHNOLOGIES

The Centre for Neurotechnology works with **McLaren Applied Technologies** through joint funding and supervision of CDT Neurotechnology student **James Clarke**, on the project: *Integrated Sensor Suite to Investigate Neurological Dysfunction in Balance.*

BACKGROUND/ CONTEXT

Mr James Clark ('James') graduated with an MEng in Mechanical Engineering from Imperial College London (ICL) in 2014. During his MEng thesis, he worked on a novel flexible insole to track foot contact force for arthritis patients that is now in the process of being translated as a medical product. Subsequently, he worked as an engineer for the start-up company GyroGear, where he designed and built a prototype wearable glove to stabilize tremor for patients with Parkinson's disease. The prototype he constructed was awarded first prize the 2015 Founders Forum FFactors start-up competition.

James joined the EPSRC CDT Neurotechnology for Life and Health in October 2015 as part of cohort 2. He is now in the first year of his PhD in the Biomechatronics Laboratory in the Department of Mechanical Engineering at ICL, working on the project Integrated Sensor Suite to Investigate Neurological Dysfunction in Balance. The project is co-sponsored (50/50) between McLaren Applied Technologies and the CDT Neurotechnology

ACTIVITIES

"The goal of my doctorate is to create a wearable, system that will detect, fuse, and transmit sensor data from foot contact force, muscle action, and physical motion for assessment and treatment of patients with neurological and/or movement disorders impacting balance. The combination of academic and commercial sponsorship has given me a perspective that I hope will lead to a unique prototype system." states James. "Our first planned application of the system will be in balance monitoring of patients with Parkinson's disease. Demonstrating efficacy on this clinically relevant problem will provide a basis for widespread clinical use....

Though only one-year into the project, James has produced a new low-power MARG (Magnetic, Angular Rate, and Gravity) sensor package which can, in real-time, fuse inertial measurements with additional inputs. He has combined this sensing system with patent pending mechanomyography (MMG) sensors as well as developed a copper etching fabrication process to produce 'sheets' capable of force measurement within clothing, shoes and orthotics. Tests integrating these sensors as measurement of foot contact force (hence balance) used in parallel with inertial and muscle measurement systems have been completed, establishing a complete sensor system to be enhanced in later stages of the project.

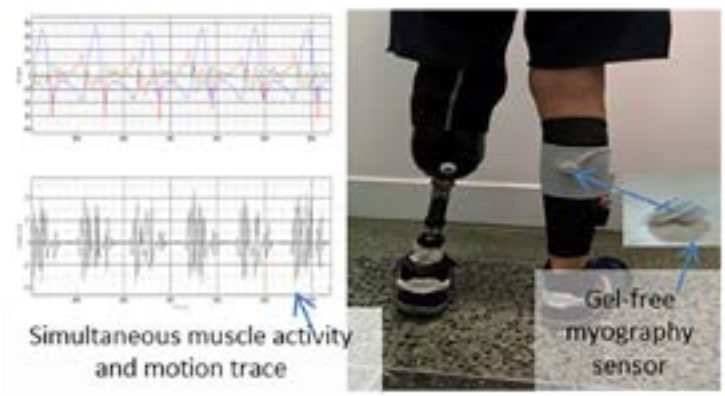
"THE CO-SUPERVISION AND RESOURCES BETWEEN MCLAREN AND IMPERIAL COLLEGE HAS OPENED RESEARCH POSSIBILITIES THAT WOULD NOT HAVE EVOLVED OTHERWISE."

James Clarke

OUTCOMES

McLaren Applied Technologies and ICL see immediate application for the wearable medical system in treatment of a wide range of neurological conditions. This project will provide a basis for new rehabilitative therapies; this potential triggered the industrial/academic collaboration.

A first generation hardware system consisting of force, muscle activity, and movement sensors has been developed (see figure below). The system has been tested on healthy subjects. Preliminary work in multimodal signal fusion has also been completed. This work provides a basis for a fully functioning system that will collect and fuse data for balance studies.



Force sensor 'sheet' with cell phone app output. The phone screen captures the sensor force profile

"MCLAREN APPLIED TECHNOLOGIES IS ON A RELENTLESS MISSION TO IMPROVE LIVES BY WORKING WITH LIKEMINDED VISIONARIES SUCH AS IMPERIAL COLLEGE LONDON."

Dr Adam Hill, Chief Medical Officer, McLaren Applied Technologies

AWARDS AND IMPACT

Through pooling resources and knowledge on this project, both McLaren Applied Technologies and ICL have expanded their capabilities as well as built on this capital in other work. James's work has spawned a growing, shared network, which has forged new industrial-academic partnerships. The collaboration has led directly to the EPSRC ICASE program (Oct 2016-Oct 2020) sponsored by McLaren Applied Technologies: Sensory Motor Interface with Lower Extremity Exoskeletons (SMILE), which is tracked to expand the

developed sensor suite into a control system for lower limb exoskeletons. Work in the program has also triggered commercial support of the patent Biomechanical Activity Monitoring by the private venture firm Imperial Innovations. James's work with Applied Technologies and ICL also contributed to the award: Most Promising Innovation in Robotics from the UK Institute of Engineering Technology (June 2016).

Public engagement events:

To date, James has presented "The application of "F1 technology" to healthcare" as a part of this program in the following venues:

- A Pint of Science (May 2016): The developed hardware was the centrepiece of the lecture and hardware demonstration "Robots on Fire" as a part of the UK Science series "A Pint of Science".
- London Tech Week (June 2016): James demonstrated his work a part of the showcase launch of "London Tech Week", which was attended by the Mayor of London and invited industrialists, investors and entrepreneurs.
- Imperial College Festival (June 2016): James demonstrated his prototype to a lay audience of 1000+ as a part of the Imperial College Festival.
- BBC Click Live (Nov 2016 Studio; Dec 2016 TV Broadcast): James's work was showcased on the first live broadcast of BBC Click, the BBC's 'technology flagship' show
- FT article for front cover of FT Special Report: Innovation in Healthcare. Highlighted Applied's work including partnership with Birmingham Children's hospital and Imperial College London.
- I'm an Engineer, get me out of here!" (Nov 2016): James has engaged pupils across the country, finishing as the Winner of the Diagnosis Zone in "I'm an Engineer, get me out of here!"

Snapshots of James Clarke and CDT-aligned student Christopher Caulcrick (awardee of the ICL-McLaren Applied Technologies ICASE project) at the broadcast BBC Click Live on Nov 14 (backstage left, onstage, right).

2

RESEARCH CASE STUDY

CLINICAL COLLABORATION

DR PAUL BENTLEY

The CDT Neurotechnology project *Virtual physiotherapy for assessment and training of arm function*, brings together clinicians and bioengineers to develop rehabilitation aids for stroke patients.

BACKGROUND/ CONTEXT

Dr Paul Bentley is a Senior Clinical Research Fellow and Consultant Neurologist within the Division of Brain Sciences at Imperial College London. As a clinician, he specializes in neurology and stroke. After training at Cambridge and UCL, he undertook a research fellowship in the Psychology Department at Harvard, and a PhD in Cognitive Neuroscience at UCL. He was awarded a Stroke Association Clinical Fellowship and Department of Health New Blood Award. He is the first UK neurologist to have been dually-accredited in stroke medicine by the Royal College of Physicians.

Dr Bentley has been working with the Human Robotics Group in the Department of Bioengineering, through the EPSRC CDT in Neurotechnology for Life and Health, to develop a bedside "hand and brain training" rehabilitation aid for stroke patients. The project also involves the Helen Hamlyn Centre for Design at the Royal College of Art, and the Imperial NHS Stroke Unit.

ACTIVITIES

"We have developed the gripAble™ device to improve arm and cognitive function of patients who have mild to severe arm weaknesses. Unlike other therapies currently on the NHS, gripAble™ is a low cost device that is accessible to patients with a wide range of disabilities, and can be used easily in hospitals or at home. As such it could increase availability and intensity of physiotherapy – that has been shown to be an important factor in patients' outcome, while potentially saving the National Health Service millions of pounds."

CDT student Rajinder Lotay, working with Dr Bentley and Professor Etienne Burdet of the Human Robotics Group, is now taking this research further, in a MRes-PhD program titled 'Virtual physiotherapy for assessment and training of arm function'. After just two years of work, Rajinder has developed and trialled software that optimizes learning of novel dexterity tasks of upper and lower arm function. Additionally, he has developed an automated method by which upper and lower arm function can be quantified, that compares favourably with conventional physician-based clinical ratings.

The gripAble™ device, in conjunction with software developed by Rajinder, is already being used by physiotherapists, in Imperial College NHS Trust, as well as in community rehabilitation centres, and patients' homes, in North London. The close working relationship with clinicians, has enabled scientists in the Imperial College Bioengineering Department to identify the most important neurological healthcare needs, and also to experience firsthand the practical constraints of clinical settings.

"THE PROJECT PROVES THAT BIOENGINEERS WORKING ALONGSIDE CLINICIANS CAN QUICKLY DEVELOP PRACTICAL INNOVATIONS FOR COMMON HEALTHCARE PROBLEMS SUCH AS STROKE."

Paul Bentley

OUTCOMES

The project is focused on having a large impact across healthcare policy, strategic changes in rehabilitation provision, and with a goal to specifically have a social impact on both patients and their carers, i.e. through allowing for and improving assessment and rehabilitation of patients with movement impairment, and also allowing for self-directed assessment and rehabilitation by patients or with their loved ones at home.

The project has already had a direct impact on one new clinical collaboration with the North London Community Rehabilitation team, who will be taking gripAbleTM and software into patients' homes. Added to this, the team are in early discussions with other research groups both internally at Imperial and externally with other London based research hospitals, to bring collaborations with more patients suffering from different upper limb disability conditions such as trauma.

The gripAble™ enterprise, utilizing software partly designed by Rajinder, is being developed as a startup company with the assistance of Imperial College's commercial partner company, Imperial Innovations. The developers of gripAbleTM have been funded to attend a healthcare accelerator program (Dubai 100) that will facilitate investment and global partnerships to take the concept from prototype to successful commercialization during 2017.

AWARDS AND IMPACT

Awards and further funding for the gripAble™ project:

- NHS England Innovation Challenge Prize for Rehabilitation, 2016
- UK Stroke Forum Patients Carers and Public Involvement Silver Prize, 2015
- HEFCE Higher Education Innovation Funding Proof of Concept Award of £47K, 2016/7 – will enable a novel ergonomic design to be manufactured along with a pressure-mould for economical mass manufacture.
- Imperial College Private Patients clinical PhD Fellowship (£187k) to support a clinical training fellow to test the software and devices developed by Rajinder on patients
- TechUK award aided in software development for startup's tablet application
- Health 2.0 'Top 10 must see start-ups of 2016' showcase – software used during demo and to help win award
- Oxbridge OneStart International Healthcare Accelerator Award, Runner-Up, 2015

Public engagement events:

- The Imperial Festival
- Science Museum "Lates" - computer gaming and science
- Unbound Digital technology conference Health 2.0 (Silicon Valley)

gripAble™ has also been covered by the media, including the Sun and CBS News.

Imperial College Centre for Neurotechnology
www.imperial.ac.uk/neurotechnology