Workshop: Bionic Technologies & Implantable Robots

Code: WAM05 | Wednesday, 26th June

Royal Geographical Society

Co-Chairs and Organisers:

Pierre E. Dupont, Boston Children's Hospital, Harvard Medical School, U.S.A.
Arianna Menciassi, The BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy

Sponsored by:

NHS National Institute for Health Research

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08:30-09:00	**Registration and Coffee**
09:00	**Opening: Welcome & Introduction** *Pierre Dupont, Boston Children's Hospital, Harvard Medical School, USA* *Arianna Menciassi, The BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy*
09:10	**Therapeutic Strategies for Cardiac Disease Using Soft Materials, Structures and Devices** *(Keynote) Ellen T. Roche, Massachusetts Institute of Technology, U.S.A.*
09:45	**Wireless Epidermal Fingertip Devices for Human Sense Restoration and Augmentation** *Gaetano Marrocco, University of Roma Tor Vergata, Italy*
10:20	**Ultra-thin Freestanding Polymeric Films Technologies for Soft and Conformable Electronics** *Virgilio Mattoli, Italian Institute of Technology, Italy*
10:55-11:15	**Coffee Break**
11:15	**Soft Bioelectronic Implants** *John A. Rogers, Northwestern University, U.S.A.*
11:50	**Bionic Humanoid - An Elaborate Human Model for Medical Innovation** *Fumihito Arai, Nagoya University, Japan*
12:25	**Round Table**
13:00	**Lunch**

Keynote Speaker:

Ellen T. Roche, Assistant Professor – Dept. of Mechanical Engineering/Institute for Medical Engineering Science, MIT, USA

Title:

Therapeutic Strategies for Cardiac Disease Using Soft Materials, Structures and Devices

Abstract:

Future implantable cardiovascular devices should be a multi-targeted, synergistic combination of (i) structural repair (ii) active assistance and (iii) biological therapy. This seminar will focus on representative implantable cardiac devices that I have worked on in each of these three areas, each addressing an identified shortcoming of existing technologies. In terms of structural repair devices, I will discuss a minimally invasive delivery system for atraumatic repair of intracardiac defects. As regards active assist devices I will discuss the modelling and design of a bioinspired soft active material technology that enabled the fabrication of a robotic direct cardiac compression device whose design mimics the orientation of the heart muscle. In vivo testing of this device has demonstrated that it is possible to improve cardiac output without the need for a blood-contacting approach in an acute heart failure animal model. Building on the platform of soft robotic approaches to enhance organ function, I will discuss pediatric cardiac assist devices and mechanical devices to enhance respiratory function. Lastly, to illustrate examples of enhanced biological therapy, I will discuss the use of biomaterials as vehicles for cell delivery and a targeted, refillable bio-implant for increasing retention of therapy in the heart, which enables repeated local administration of biological or pharmacological delivery, and some preliminary steps to combine these mechanical and biological therapies in order to improve delivery of drugs and modulate the host response.

Biography

Ellen Roche is currently the Keck Career Development Assistant Professor at the Institute for Medical Engineering and Science and the Department of Mechanical Engineering at the Massachusetts Institute of Technology. She directs the Therapeutic Technology Design and Development Lab. She completed her PhD at Harvard University School of Engineering and Applied Sciences. Her research focuses on applying innovative technologies to the development of cardiac devices. Her research includes development of novel devices to repair or augment cardiac function using disruptive approaches such as soft robotics, combination of mechanical actuation with delivery of cell therapy, and use of light activated biodegradable adhesives.

Dr. Roche was employed in the medical device industry for over five years as a research and development engineer and understands the regulatory pathways to medical device commercialization. She holds 4 issue patents, with ten pending and is the authors of over 40 conference/journal papers. She is the recipient of multiple awards including the Fulbright International Science and Technology Award, the Wellcome Trust Seed Award in Science, an American Heart Association Pre-Doctoral Award and a National Science Foundation CAREER Award.

Speaker:
Fumihito Arai, Nagoya University, Japan

Title:
Bionic Humanoid - An Elaborate Human Model for Medical Innovation

Abstract:
We have developed Bionic Humanoid, which is an elaborate human model equipped with sensors and actuators to serve as a substitute for and test animals. Bionic Humanoid uses artificial materials to precisely recreate the structure of the human and to mimic physical property of the human. The Bionic Humanoid can be used, for example, to quantify the requirements of medical doctors, assess surgical skills, replicate physical constraints for the development of a medical device, and provide young surgeons with training opportunities. We developed a prototype of Bionic Humanoid for medical simulator and training in eye surgery and neurosurgery in the first place. Based on the concept of Bionic Humanoid, we established Bionic Eye surgery Evaluator (Bionic-EyE) for training of peeling the inner limited membrane (ILM) which is superficial layer of retina. Bionic-EyE is equipped with bionic sensors to monitor and quantify the force applied by the operator. Bionic sensor is designed so that the sensor-embedded model recreates the structure of the human and mimics physical property of the human. Recent progress of Bionic Humanoid will be introduced and discussed for future medical innovation in R&D and surgical training.

Biography:
Fumihito Arai is a Professor of Department of Micro-Nano Mechanical Science & Engineering at Nagoya University, Japan. He also serves as a Deputy Director of Institute of Nano-Life-Systems at Nagoya University. He received Master of Engineering degree from Tokyo Univ. of Science in 1988. He received Dr. of Engineering from Nagoya University in 1993. Since 1994, he was Assistant Professor of Nagoya University. Since 2005, he was Professor of Tohoku University. Since 2010, he has been Professor of Nagoya University. He was the Vice-President for Technical Activities, IEEE Nanotechnology Council (2002, 2003).

He was AdCom Member of IEEE Robotics and Automation Society (RAS) (2009-2011, 2012-2014), and he serves as AdCom Member of RAS again since 2019. He was the Vice President for Technical Activities, IEEE RAS (2014-2015, 2016-2017). He was Editor in Chief of Advanced Robotics (2012-2017). His research fields are Micro-nano Robotics and Bio-Robotics. He received 87 awards on his research activities, for example, Early Academic Career Award in Robotics and Automation from IEEE Robotics and Automation Society in 2000, Best Conference Paper Award at ICRA2012. He is the author of 395 journal papers.

Speaker:

Gaetano Marrocco, University of Roma Tor Vergata, Italy

Title:

Wireless Epidermal Fingertip Devices for Human Sense Restoration and Augmentation

Abstract:

Radiofrequency Finger Augmented Devices (R-FAD) combine the advanced epidermal electronics typical of FADs tools with wireless communication based on passive backscattering (UHF RFID) to turn the human fingers into enhanced sensory interfaces aimed at restoring lost peripheral sensitivity in people affected by Hypoesthesia, and even expanding their senses beyond natural ones (ultrability). This talk introduces the novel architecture of a R-FAD system comprising battery-less epidermal tag shaped for the fingertip that are powered by and wirelessly interconnected to a wrist-mounted reader module. Starting from the electromagnetic challenges due to the close proximity of the lossy human body, the wrist-to-fingers channel is investigated to derive upper-bounds performance of the wireless link. Fully-functional R-FADs, conceived as assistive devices, are experimented in realistic scenarios to provide impaired subjects with severe loss of thermal feeling or eyesight deficiency with a real-time feedback about the temperature and even the material of the objects they interact with. Finally, the presentation paves the way to original applications of such devices in the context of cognitive neuroscience where it is of great interest to asses if a training with R-FAD providing a 'transduced' physical sensitivity, may trigger the cognitive re-mapping of the abstract/mental representation of the loss senses.

Biography:

Gaetano Marrocco is a full professor of Electromagnetics at the University of Roma Tor Vergata. Italy where he is the director of the Medical Engineering School and Chair of the Pervasive Electromagnetics lab (www.pervasive.ing.uniroma2.it). In 25 years of activity he initially worked on numerical methods for electromagnetic modeling of aerospace, naval, avionic and biomedical devices. Since 2003 he pioneered the design of RFID antennas and sensors for application to bodycentric systems, environmental monitoring, ubiquitous sensing through flying sensors. In the last five years he has been developing epidermal antennas in UHF frequency, integrated with chemical sensors for the measurement of temperature, pH, sweat and breath.

He is co-founder and president of the spin-off Radio6ense (www.radio6ense.com) that is active in the Industrial Internet of Things.

Speaker:
Virgilio Mattoli, Italian Institute of Technology, Italy

Title:
Ultra-thin Freestanding Polymeric Films Technologies for Soft and Conformable Electronics

Abstract:
The increasing demand for portable and ubiquitous electronic applications generated a great interest in the new emerging conformable electronics, able to adhere and conform to skin or other tissues and surfaces. Targeted applications include wearable electronics, human-machine interfacing, conformable electrode for bio-electric signals, as well as personal healthcare monitoring systems. In this framework, functional freestanding polymeric nanofilms could be a key technology for the development of effective ultra-conformable devices. Freestanding nanofilms are large area (square cm) ultra-thin (tens-hundreds of nm) polymeric films, showing as an intrinsic property the capability to adhere and conform spontaneously to surfaces due to physical interactions (i.e. Van Der Waals), making possible the intimate contact between such films and virtually any surface, including skin. In this talk the last achievements obtained by our group in this field will be reviewed, with particular focus on the use of freestanding and tattoo-like ultrathin dielectric and conjugated polymeric films for assembling/developing of conformable electronic (passive and active) components and circuits. Final objective of our research is the development of ultra-thin yet robust complete circuits that can be used as free-standing nano-membranes, easily transferred to surfaces with complex topographies, such as skin (e.g., “tattoo electronics”).

Biography:
Virgilio Mattoli received his Laurea degree in chemistry (with honours) from the University of Pisa and the Diploma in Chemistry from the Scuola Normale Superiore of Pisa in 2000. In 2005 he received his PhD in bio-engineering (with honours) from Scuola Superiore Sant’Anna, with a thesis focused on the control and integration of miniaturized devices for environmental application. In summer 2004 he was visiting researcher at the University of Stanford, Center for Design Research, where he focused his activity on sensors and controls modules for biomimetic robotics applications. In 2005 and 2008 he was a short term visiting researcher at Waseda University (Tokyo, Japan) working on a bio-inspired mini-robot and on development of ultra-conformable polymeric films. From June 2008 to October 2009 he obtained a temporary position of Assistant Professor of bioengineer engineering at the Scuola Superiore Sant’Anna (SSSA).

From November 2009 to July 2015, he has been a Team Leader of the Smart Materials Platform in the Center for Micro-BioRobotics @SSSA of the Istituto Italiano di Tecnologia. In August 2015, he obtained a permanent position as Researcher Technologist at the Center for Micro-BioRobotics @SSSA. His main research interests include: smart nano- and bio-inspired materials, ultra-thin polymeric films, tattoo electronics, sensors, and biorobotics. He is currently involved in several research projects on these topics. He is author or co-author of more than hundred twenty articles on ISI journals, of about fifty full papers published in peer-reviewed international conferences proceedings, of about thirty invited talks and of several deposited patents. [H-Index: 30, H10-Index: 93, Cit. 3258; source Scopus @29-04-2019]

Speaker:
John A. Rogers, Northwestern University, Departments of Materials Science and Engineering, Biomedical Engineering and Neurological Surgery, Center for Bio-Integrated Electronics, U.S.A.

Title:
Soft Bioelectronic Implants

Abstract:
This talk will summarize recent developments in soft electronic systems as chronic implants to restore, enhance and/or control organ function. The content focuses on various ultraminiaturized, wireless, battery-free platforms, including examples in (1) microscale light emitting diodes for neural stimulation and recording, (2) closed-loop systems for control of bladder function and (3) optoelectronic cardiac pacemakers.

Biography:
John A. Rogers is the Louis Simpson and Kimberly Querrey Professor of Materials Science and Engineering, Biomedical Engineering and Neurological Surgery at Northwestern University, with affiliate appointments in Mechanical Engineering, Electrical and Computer Engineering and Chemistry, where he is also Director of the newly endowed Center for Bio-Integrated Electronics. He has published more than 650 papers, is a co-inventor on more than 100 patents and he has co-founded several successful technology companies. His research has been recognized by many awards, including a MacArthur Fellowship (2009), the Lemelson-MIT Prize (2011), and the Smithsonian Award for American Ingenuity in the Physical Sciences (2013) – and most recently the Benjamin Franklin Medal from the Franklin Institute (2019). He is a member of the National Academy of Engineering, the National Academy of Sciences, the National Academy of Inventors and the American Academy of Arts and Sciences.