International seminar on cardiovascular biomedical engineering

June 3rd, 2014,

:Envihab

Organiser: Dr. Carole Leguy
Marie Curie Postdoctoral fellow, space physiology division, DLR

Part 1: Advances in vascular research

13h00:13h10 **Opening**
Dr. Carole Leguy

13h10:13h30 **Cardiac Vibration Signals: Old Techniques New Applications**
Dr. Kouhyar Tavakolian, University of North Dakota, USA.

13h30:13h50 **Targeting the arterial wall in hypertension**
Prof. Pierre Boutouyrie, Hôpital Européen George Pompidou, Paris, France.

13h50:14h10 **Fully integrated real time multi-wavelength photoacoustics for early disease detection**
Dr. Peter Brands,Esaote Europe, Maastricht, the Netherlands.

14h10:14h30 **Mechanical characterization of healthy and diseased arteries in vivo using ultrasound**
Dr. Richard Lopata and Dr. Marcel Rutten, Eindhoven University of Technology, the Netherlands.

14h30:14h50 **Coffee Break and refreshments**

Part 2: Modeling of vascular system and medical robotic

14h50:15h10 **A case for concurrent cardiovascular measurements; estimating central nervous system time delays**
Msc. Alexandre Laurin, Simon Fraser University, Vancouver, Canada.

15h10:15h30 **Cardiovascular response to gravitational stress: a modeling approach**
Msc. Joke Keijsers, Space physiology division, DLR (Cologne).

15h30:15h50 **Minimally invasive robotic surgery and image processing aspects in the DLR MiroSurge system**
Inf. Martin Groeger, Dr.-Ing. Bernhard Kuebler, Robotics and Mechatronics Center, DLR (Oberpfaffenhofen / Munich).

15h50-16h10 **CARA concept: the Cardiovascular Robotic Assistant**.
Dr. Carole Leguy, Space physiology division, DLR (Cologne).

Abstracts

Cardiac Vibration Signals: Old Techniques New Applications

Dr. Kouhyar Tavakolian
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With every heartbeat the body is set to a series of vibrations that can be recorded using different devices from different places on the body. The techniques for recording these signals are not new and have been around for more than a century (e.x. Seismocardiography and Ballistocardiography). However, new sensor and signal processing developments have provided us with a unique chance to use these techniques in monitoring cardiovascular dynamics. In this talk a quick overview of these technologies and their novel application will be provided.

Arterial mechanics, mechanical stresses and arterial fragility

Prof. Pierre Boutouyrie, MD, PhD
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Professor Boutouyrie is a world renowned expert in vascular diseases with a focus on hypertension. During his talk, he will review the latest research on arterial biomechanics and fragility, from both a clinical and mathematical approach. Furthermore, he will explore the consequences of space flight on arterial wall structure, and the significant impact of space research on the understanding of cardiovascular responses in a healthcare context.

Fully integrated real time multi-wavelength photoacoustics for early disease detection

Dr. Peter Brands
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The objective of FULLPHASE is the transition of photoacoustic (PA) imaging from a lab-based technique to a low-cost portable multi wavelength combined PA and US system. In order to reach that goal, the FULLPHASE partners offer specific expertise over complementary backgrounds in diode laser technology, laser beam shaping, ultrasound imaging technology, and system integration. The impact of the FULLPHASE system will be shown in oncology, rheumatology and cardio vascular disease and will integrate different scientific and technological expertise, for point-of-care early diagnosis.

Mechanical characterization of healthy and diseased arteries in vivo using ultrasound

Dr. Richard Lopata and Dr. Marcel Rutten
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In recent years, functional ultrasound imaging has been boosted by the availability of raw radio-frequency ultrasound data at sufficiently high frame rates. In the Cardiovascular Biomechanics group at Eindhoven University of Technology, functional imaging techniques, such as ultrasound strain imaging and non-invasive flow imaging are being developed. Combined with suitable biomechanical models, these data can be used for mechanical characterization of tissue (= elastography), e.g., the diseased vascular wall or the myocardium, and the non-invasive assessment of the blood pulse pressure and waveform. In vitro and ex vivo platforms have been developed for experimental verification and validation of these techniques for proper pre-clinical validation, consisting of mock circulatory systems in a variety of shapes and sizes, but also, tensile testing and histological examinations. Furthermore, the use of realistic tissue models, such as polymer-based phantoms, porcine waste material obtained at the slaughterhouse, and excised human samples provides a suitable framework for testing. Parallel to these theoretical and experimental developments, large patient studies are conducted in several clinical sites and university medical centres in Europe, to introduce these methods into the clinical arena and investigate their feasibility and sensitivity.

A case for concurrent cardiovascular measurements; estimating central nervous system time delays

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Estimation of the time it takes for blood pressure changes to affect heart rate, and vice-versa, gives us important insights on the functioning of the central nervous system. It is well known that many conditions affect these delays, namely concussions, diabetic neuropathies, Parkinson’s disease or dementia, etc. In people suffering from these pathologies, longer delays can mean the difference between balance and falling, staying conscious and fainting, as well as being discharged from or remaining in a hospital. I will present an updated methodology for estimating time delays in closed loop systems with sporadic interaction, a setup comparable to the blood-pressure to heart rate system. It is our goal to develop early quantitative diagnosis protocols for the cited neuropathologies.

The cardiovascular response to gravitational stress: a modeling approach

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Orthostatic intolerance is observed in astronauts after spaceflight, in patients with spinal cord injury and in the elderly, and can result in critical events as syncope. In order to better understand the causes of this extreme blood volume shift towards to lower body and the more compliant veins, a better understanding of the cardiovascular response to orthostatic stress is necessary. The goal is to develop a 1D pulse wave propagation model capturing blood pressure and flow hemodynamics with a focus on the systemic veins and the influence of the surrounding muscles. Later on, regulation mechanisms as the baroreflex and local auto-regulation will be included to better simulate the physiological response to orthostatic stress.

The modeling approach allows us to isolate certain physiological mechanisms, as the muscle pump effect and blood pooling, and determine their relative importance in blood pressure regulation under orthostatic stress. In the future, a full model of the cardiovascular circulation will be validated while comparing simulated and in vivo data.

Minimally invasive robotic surgery and image processing aspects in the DLR MiroSurge system

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German Aerospace Center, DLR, Oberpfaffenhofen / Munich.

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Different aspects of minimally invasive robotic surgery are presented in the example of the DLR MiroSurge system. MiroSurge is a versatile robotic system for the surgery of the future, developed by the Robotics and Mechatronics Center (RMC) at DLR Oberpfaffenhofen. Next to the setup of the robotic system and its components (robotic arms, instruments, endoscope, 3d display, surgeon console), the way how the surgeon uses the system to perform surgery and the feedback provided (vision and force/torque) are described. Using image processing techniques, support of the surgeon by autonomous tasks is possible, e.g. by automated camera guidance and motion compensation of the beating heart. Kinaesthetic feedback of the system can be extended by ultrasonic Doppler supported (quasi tactile) vessel detection.

CARA concept: the Cardiovascular Robotic Assistant.

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The main objective of the Cardiovascular Robotic Assistant project, CARA, is to develop a comprehensive robotic system that will provide assisted measurement of cardiovascular hemodynamic parameters with ultrasound imaging technology. Non-invasive ultrasound imaging is a tool widely used for the diagnosis of cardiovascular diseases such as atherosclerosis, abdominal aortic aneurysm, and chronic venous insufficiency. However, performing in vivo ultrasound measurement requires high expertise, often resulting in prohibitive cost. To overcome this major limitation, we aim at transitioning from an ultrasound system remotely controlled by an expert, as used for human centrifuge and telemedicine, to image based control algorithms. This technology would lead to user-free control of the probe. The benefits thereof include increased ultrasound reliability and reproducibility with new measurement possibilities such as 3D geometry tracking, integration of physiological and anatomical data (from imaging technics as MRI/CT), and long-term recording. Such a system is founded upon the transfer of knowledge between space research, biomedical engineering and cardiovascular research, and, will be an important tool for both space physiology, and health care.