Plenary Lectures

Sunday, July 30

7695 Su, 17:30-18:30 (P4)
Human Factor – Factor Human

P. Hupfer. *TÜV SÜD, München, Germany*

External forces acting on human beings and the forces the latter need to summon in order to survive are two of several factors from our evolutionary history spanning thousands of years. Moving within the gravitational field, hunting for food, an unexpected fall or intended leap are just a few examples of the requirements to be satisfied by the natural interplay of forces and counter-forces, for which our skeletal-muscular system in particular had to evolve to a superior level in the competition with other living beings.

Technology has created new framework conditions for this natural and familiar interplay of forces within an incredibly brief period of time. Today, in their interplay with technology, people experience new types of forces within unfamiliar time periods. In order to benefit people, technology must master static and dynamic forces in such a way that they do not result in physical harm or technophobia due to feelings of unease.

Technology whose forces act in a people-oriented manner follows a three-stage protection approach:

- Stage 1: The technology itself must be designed in such a manner that events which might harm people and their environment are prevented with a high degree of certainty.
- Stage 2: Should the technical system nevertheless fail, in spite of these primary protection measures, and failure result in hazards for people, targeted technical counter-measures serve to fend off possible impacts on people and their environment.
- Stage 3: The last stage of this protection approach provides for protection systems in people's physical environment to prevent or mitigate bodily harm.
- TÜV SÜD provides technical services for the benefit and protection of people and their environment in numerous areas of technology. The interfaces at which forces resulting from our use of technology may harm and injure people are thus equally numerous.

The forces acting on our bodies while skiing, a roller-coaster ride which is supposed to be enjoyable and not result in injuries or trauma, car crashes, and, last but not least, the use of sensitive medical devices under the conditions of normal physical movement are examples of the methodology to be used for designing people-oriented technology.

7907 Su, 17:30-18:30 (P4)
Healthcare and technology – Innovations for the future

B. Montag. *Siemens AG Medical Solutions, Forchheim, Germany*

Global mega-trends drive the need for improved quality of care at reduced cost. We believe that the potential for efficiency gains in healthcare is huge. The focus on medical workflow improvement, powered by integrated IT solutions combined with innovative technologies – should result in higher satisfaction of both patients and physicians.

Monday, July 31

7791 Mo, 10:00-10:30 (P7)
Biomechanics of the heart and lungs: Challenges in multi-scale modelling

P. Hunter, M. Tawhai. *Bioengineering Institute, University of Auckland, New Zealand*

Multi-scale models of cardiac structure and function that integrate electrical activation of the myocardium with large deformation ventricular mechanics and coronary blood flow are currently under development. They link the application of conservation laws (mass, momentum, current, etc) at the tissue level to a variety of cellular processes such as ion channel electrophysiology, calcium transport, myofilament mechanics, metabolic pathways and (to a limited extent) signal transduction. They also incorporate the detailed fibrous-sheet structure of the myocardial tissue and use orthotropic constitutive laws based on the inhomogeneous material axes. Numerical techniques include low density high order (cubic Hermite) finite elements for mechanics and material point based high density low order finite elements for the reaction-diffusion equations governing electrical wave propagation. Similarly, multi-scale models of the lungs link gas flow in the lung airways (both the conducting and respiratory airways) with blood flow in the pulmonary vessels (including alveolar capillaries for gas exchange) and the large deformation mechanics of the lung tissue. The models are finding applications in clinical diagnosis, virtual surgery and the development of medical devices, but not yet drug discovery or toxicology. To achieve the latter the models must achieve much greater sophistication in the representation of cellular processes, particularly signal transduction and the regulation of intracellular ions. This talk will present an overview of the current state of cardiac and pulmonary modelling at the cell, tissue and organ levels, with a focus on mechanics.

References

Nash M.P., Hunter P.J. (2001). Computational mechanics of the heart. J. Elasticity 61(1–3): 113–141.

Hunter P.J., Pullan A.J., Smaill B.H. (2003). Modelling total heart function. Annu. Rev. Biomed. Eng. (Annual Reviews, California) 5: 147–177.

Tawhai M.H., Hunter P.J., Tschirren J., Reinhardt J., McLennan G., Hoffman E. (2004). CT-based geometry analysis and finite element models of the human and ovine bronchial tree. J. Appl. Physiol. 97(6), 2310–2321.

Tuesday, August 1

7909 Tu, 10:00-10:30 (P18)
Biomechanics research and sports medicine's future: meeting the challenges of keeping your knee and shoulder healthy

S.L.-Y. Woo. *Musculoskeletal Research Center, Department of Bioengineering, University of Pittsburgh, Pittsburgh, USA*

The motion of the musculoskeletal system is stabilized and guided by ligaments and tendons, bands of tough connective tissues that traverse the joints of the body and bind the skeleton. Their nonlinear tensile and viscoelastic properties are well suited to maintain smooth joint motion at low loads, while limiting excessive displacement between the bones at higher loads. However when participating in sports, knee ligament injuries, rotator cuff tears and shoulder dislocations can occur frequently. Research has found that a ruptured medial collateral ligament (MCL) of the knee can heal spontaneously while the anterior cruciate ligament (ACL), as with the shoulder tendons and capsule, have poor intrinsic capability for healing and require surgical reconstruction to restore joint stability. Currently, many surgical procedures are still less than ideal.

In this lecture, we will present a series of novel experimental and mathematical studies including characterization of knee ligaments and their homeostatic responses on clinical practice management and healing of the MCL that contributed to the change in clinical management paradigm. With the new functional tissue engineering approaches, such as the use of growth factors, gene and cell therapy, and biological scaffolding, it is now possible to improve the properties of the healing tissue. Also, with a novel testing system based on robotic technology the complex function of the ACL and shoulder tendons and capsule is achieved and new surgical approaches are suggested.

It is clear that the complexity of ligaments and tendons will continue to challenge us.

Thus, efforts are needed to develop a team approach between biologists, biochemists, biomedical engineers, physicians, and surgeons, such that a seamless collaboration will lead to better outcomes for patients with ligament and tendon injuries.

It is clear that biomechanics will play a major role to move from in vitro to in vivo studies including evaluation of rehabilitation protocols and exercise regimens to maintain the health of our knee and shoulder joints.