Wearable Technology and its Applications in Rehabilitation: (10:00-12:00)

Paolo Bonato, Ph.D.
Department of Physical Medicine and Rehabilitation, Harvard Medical School
The Harvard-MIT Division of Health Sciences and Technology, MA, USA

The tutorial will provide an introduction to the rapidly evolving field of wearable technology and a discussion of the potential revolutionary role of this technology in rehabilitation. The speaker will present different wearable technologies including examples of systems that rely on wireless miniature sensors and systems based on textile solutions to achieve physiological monitoring. He will also discuss techniques to gather physiological data using different wearable technologies. A portion of the tutorial will be devoted to introduce attendees to signal processing and data analysis techniques designed to derive clinically-relevant information from data recorded using wearable systems. Attendees will be introduced to recent clinical applications of wearable technology including the use of wearable sensors to monitor motor activities performed by individuals in the home and community settings, the use of wearable systems to assess quality of movement in subjects undergoing treatment, and the use of wearable devices in conjunction with robotics and virtual reality to implement rehabilitation interventions.

Biomechanical testing and simulation techniques in skeletal research - the importance of hierarchy (10:00-12:00)

Ralph Müller, Ph.D.
Institute for Biomechanics, ETH Zürich, Switzerland

Biomechanical testing is the gold standard to determine bone competence, and has been used extensively. Direct mechanical testing provides detailed information on overall bone mechanical and material properties, but fails in revealing local properties such as local deformations and strains and does not permit quantification of fracture progression. Therefore, we incorporate several imaging methods in our mechanical setups to get a better insight into bone deformation and failure characteristics on various levels of structural organization. Our aim is to develop an integrative approach for hierarchical investigation of bone, working at different scales of resolution ranging from the whole bone to its ultrastructure. At the macroscopic level, we use high-resolution and high-speed cameras which allow visualization of global failure behavior and fracture initiation with high temporal resolution. At the microscopic level, bone microstructure, i.e. trabecular architecture and cortical porosity, are known to influence bone strength and failure mechanisms significantly. For this reason, we develop image-guided failure assessment techniques, also referred to as functional microimaging, allowing direct time-lapsed three-dimensional visualization and computation of local displacements and strains for better quantification of fracture initiation and progression. While the resolution of conventional desktop micro-computed tomography is typically around a few micrometers, computer tomography systems based on highly brilliant synchrotron radiation X-ray sources permit to explore the sub-micrometer world. This allows, for the first time, to uncover fully nondestructively the 3D ultrastructure of bone including vascular and cellular structures and to investigate their role in the development of bone microcracks with an unprecedented resolution. These experimental approaches are always combined with appropriate simulation techniques allowing modelling of the experimental setup and with that to gain a better understanding of the mechanical behavior of the material. Using such a dual approach, we are able to show that differences in bone mechanical properties observed macroscopically in bone can be explained, to some extent, by their differences in microstructural architecture and porosity assessed with high-resolution and large-scale simulation techniques. In conclusion, functional microimaging in combination with mechanical simulation techniques is extremely valuable in studying bone failure mechanisms in a hierarchical fashion.

Foot Biomechanics: Clinical Applications: (13:00-15:00)

Peter R. Cavanagh, Ph.D.
Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, USA

This tutorial will review current approaches to biomechanical analysis of the foot with an emphasis on clinical applications. It will include an in-depth review of the role of biomechanical factors in diabetic foot disease and in orthopaedic surgery. A summary of new developments from the 2008 meeting of i-FAB (the International Foot and Ankle Biomechanics Community http://www.i-fab.org/) will also be presented. The tutorial will conclude with an assessment of future research opportunities in the field.

Biomechanical Modeling and Simulation: (13:00-15:00)

Scott Delp, Ph.D.
Mechanical Engineering Department; Bioengineering Department, Stanford University, CA, USA

Computational models provide a framework for exploring the biomechanics and neural control of movement. In recent years, simulations of human and animal movement have become widely used to explore a range of basic scientific questions, study the mechanisms of various diseases, and assist in the design of medical devices. This tutorial will provide an introduction to musculoskeletal modeling and the application of simulations in the study of movement. Specifically, the tutorial will:

- motivate the use of simulations in studies of human and animal movement,
- review the components of a simulation, including models of muscle-tendon mechanics, musculoskeletal geometry, skeletal dynamics, and neural control,
- provide examples of simulations that have provided insight into important scientific questions and clinical problems,
- discuss some of the limitations of current simulations and suggest future research directions.