Special issue on Advances in biomechanics: from foundations to applications

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Biological systems are complex, both functionally and geometrically, heterogeneous, and have sophisticated structural hierarchies. Multidisciplinary modelling and simulation efforts to deal with these systems can both provide new perspectives and solutions to biology and medicine, and push the boundaries of engineering in many directions.

Several challenges need to be faced in these basic issues, including the inherent property of biological systems to adapt to mechanical and biochemical environments, the coupling among structural, fluid, chemical and electrical fields; the inter-patient variability of loading conditions or constitutive properties. We underline the ability to deal with complex geometries and with complex material, from fluid to soft to hard ones, simulate mechanics at multiple scales, gather accurate patient-specific data, process huge nonlinear models; and how to establish validity of such models. On the other side, applications such as mini-invasive surgery and rehabilitation techniques pose demanding questions whose answers can greatly affect human life. Here, the significant development of robotics and mechatronics, with the exploitation of new materials, paves the way to great advances and raises a number of challenging issues related to human–machine interaction.

This Special Issue on *Advanced Biomechanics: from foundation to applications* presents a selection of papers ranging from biofluid mechanics and fluid–structure interaction to computational modelling of biological systems in medicine and biology, and also from multiphysics and multiscale analyses to robotic rehabilitation: complementary issues that deal with the complex world of Biomechanics from different perspectives, tackled by similar techniques and offering solutions based on advanced approaches and modern tools.

In particular, the first eight papers deal with various aspects of biological fluid mechanics. Two of them are dedicated to models of the cardiovascular network to evaluate global pathophysiological alterations in blood circulation, they are followed by three papers presenting experimental and numerical studies of the local fluid dynamics in cardiac devices or large cardiovascular vessels, which are the most common regions involved in cardiovascular pathologies. Recently, a large interest is gained by techniques for

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"in vivo" assessment of blood flow in the heart chambers and two papers are dedicated to application of imaging solutions for clinical applications of fluid mechanics. Finally, one paper is dedicated to an important application of fluid dynamics to ocular biomechanics applied to therapeutic optimization.

The following six papers focus on biological solid mechanics. One paper reviews theoretical approaches for describing soft tissue growth and remodelling, also discussing related emerging concepts. It is followed by a paper emphasizing the different biomechanical response of the human sclera in highly myopic eyes or emmetropic eyes. Two papers focus on computational modelling of cardiovascular devices, respectively dealing with textile reinforced artificial heart valves, and nitinol self-expanding stents used for the endovascular management of peripheral artery diseases. Finally, one paper deals with computational modelling of a lab-on-a-chip device for single-cell mechanical phenotyping, and one paper formulates and solves the locomotion problem for a bio-inspired crawler.

The last five papers deal with human joint modelling and application of robotic rehabilitation. Two of them are devoted to knee modelling: the first reports detailed knee models integrated in musculoskeletal dynamic models of the lower limb in order to investigate if higher approximation of passive structures such as ligaments can help to obtain more reliable knee dynamic models. The second focuses on subject-specific human joint modelling and validation of the musculoskeletal system based on advanced image technology. Three papers deal with robotic applications, an emerging field with great social and economical impact. One aims at providing self-adjustment mechanisms for orthoses that guide the joint motion while respecting their natural motion. Another proposes a novel exoskeleton for a lower limb device that compensates dynamic disturbancies in osteo-kinematic movements of the wearer. Finally, the last one presents a novel design of an underactuated hand exoskeleton with automatic finger size adaptability to assist users performing grasp tasks.

The Guest editors hope this collection could be useful for stimulating/inspiring researchers to face new and more challenging issues of either fundamental or applied nature in the rapidly developing area of Biomechanics.

Guest Editors: Paolo Bisegna, Vincenzo Parenti-Castelli, Gianni Pedrizzetti.