actuators

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Editorial

High Resolution Actuators

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Driven by increasing societal, economic, and technological pressures, high-resolution actuators must achieve ever increasing accuracy requirements and functional integration into the system. High-resolution actuators have been used for many decades for the development of actuators in different applications, such as robotics for micro- or macro-scale manipulation and assembly, scanning probe microscopy, medical, military, aerospace, robots, and, more generally, in mechatronic systems dedicated to tasks that require high-resolution features [1–7]. These actuators are often based on smart materials, flexible structures, or even on more conventional mechatronic actuators that can achieve interesting performances with a high-resolution, either in position or in force.

- The advantages of smart materials-based actuators (piezoelectric, magnetic, magnetostrictive, electroactive polymers, magnetoactive polymers, shape memory alloys, magnetic shape memory alloys, thermally active materials, *etc.*) are numerous including the high resolution of positioning and the ease of integration in miniaturized systems. Some of them can provide very high bandwidth, whilst others very high stiffness, or high range of deformation and thus of positioning.
- Optimal designs of mechatronic actuators together with appropriate control strategies have often lead to very interesting solutions in terms of force or position characteristics. Nonlinear phenomena often at the basis of the design rationale (friction, backlash, hysteresis, and so on) can be efficiently treated, either at a mechanical design level (using flexure-based mechanisms, backdrivable transmission, *etc.*) or at a control level (model-based identification, input-shaping techniques, vibrations damping), to provide the actuation with high-resolution performances in terms of position or force.

The objective of this Special Issue was to investigate new techniques, technologies, results, principles and surveys for actuators that are characterized by high-resolution performances. The issue provided an opportunity for researchers and practitioners to present their most recent accomplishments, challenges, advances in this area, and we also encourage future research directions in the field.

After a high quality reviewing process, this Special Issue on "High-Resolution Actuators" decided to retain eight papers with various applications and techniques in the topics of high resolution actuators. They are quickly summarized below.

In [8], the authors present an approach for identifying the model of a composite piezoelectric bimorph actuator dynamics; these actuators are characterized by very high resolution inherited from piezoelectric materials. The objective is to create a robust model that can be used under various operating conditions. The actuator is typified by nonlinearities such as backlashes and hysteresis. An appropriate method of identification based on hybrid master-slave genetic algorithm neural network was proposed by the authors.

In [9], a high-precision planar digital electromagnetic actuator with two displacement directions and four discrete positions is presented. One of the originalities of the digital actuator is that the mobile part can perform the 2-DOF (degrees of freedom) displacements without assemblying two 1-DOF actuators. This configuration reduces the assembly errors, thus enhancing the precision of the actuator and improving its compactness. Finally, the paper demonstrates the interest of the actuator in a linear conveyor application.

The third published article in this Special Issue, referenced in [10], deals with the mechatronic design of a novel self-sensing motor-to-joint transmission to be used for the actuation of robotic dexterous manipulators. Backdrivability, mechanical simplicity and efficient flexure joint structures are the key concepts that guided the authors for the mechanical design rationale to provide the actuator with force sensing capabilities. Overall, this mechatronic design contributes to the improvement of the manipulation skills of robotic grippers, thanks to the combination of high performance mechanics, high sensitivity to external forces and compliance control capability.

The next article, referenced in [11], presents the synthesis and the characterization of a smart composite material made up of a magnetic hybrid film and a NiTi shape memory alloy (SMA) ribbon. A particularity of this hybrid smart material is that it can be activated by temperature, electrical current, stress, and/or magnetic field, offering good expectations for actuating applications with multiphysic transduction.

In [12], the authors present the modeling and design of an actuator consisting of an electrical motor and a magnetic gear. In order to minimize the overall actuator dimensions, they suggest an optimal design and an optimal match for both devices. The paper includes a well explained theoretical part and its simulation.

The article in [13] presents the feedforward control of multi-degrees of freedom (DOF) actuators typified by multi-mode and badly damped oscillations. Such properties are, for instance, found in many multi-DOF piezoelectric actuators. The paper proposes therefore to extend an existing single-input-multiple-output (SIMO) input shaping technique into a multiple-input-multiple-output (MIMO) multi-mode input shaping technique capable of damping the vibrations without using feedback control. The paper demonstrate the efficiency of the approach by applying this to a 3-DOF piezotube actuator classically used in scanning probe microscopes.

In [14], the authors show the advantages of using piezoelectric actuators (PEA) in micro-nano-unmanned-aerial-vehicles (MAV and NAV). For that, the paper gives an overview of MAV/NAV based on PEA and introduces the readers to their functioning and principles with the governing equations and illustrative graphicals. The paper also reminds us of the challenges and raises open questions in the development of MAV/NAV and in the use of PEA for this aim.

Finally, the last paper, referenced in [15] proposes a new differential cable drive reducer which is backdrivable, has a high efficiency, and a potentially infinite reduction ratio. A prototype actuator using the reducer has been developed by the authors and integrated on a test bench and experimental characterization of its performance confirms its theoretical advantages.

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