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Editorial

Modelling and Control of Mechatronic and Robotic Systems, Volume II

Alessandro Gasparetto [1], Stefano Seriani [2] and Lorenzo Scalera [1,*]

[1] Polytechnic Department of Engineering and Architecture, University of Udine, 33100 Udine, Italy; alessandro.gasparetto@uniud.it
[2] Department of Engineering and Architecture, University of Trieste, 34127 Trieste, Italy; sseriani@units.it
* Correspondence: lorenzo.scalera@uniud.it

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1. Introduction

In modern times, mechatronic and robotic systems are developing at a faster pace than in the past [1], and research on novel solutions and applications of such devices are studied in both industrial and academic environments [2]. The modelling and control of mechatronic and robotic systems is a fundamental field of investigation, especially within the context of Industry 4.0, in which novel scenarios for manufacturing processes and production lines are strictly related to the implementation of robots, automatic machines, and cyber-physical systems.

In this scenario, it is crucial to develop kinematic and dynamic models that can predict the behavior of a mechatronic or robotic system over time, and can support the planning of the path and the trajectory that the system needs to track during its operation [3]. Furthermore, the modelling, design, and control of mechatronic devices and robots play an increasingly central role in enhancing their performance with respect to different objectives, such as energy efficiency [4] or vibration suppression, when the flexibility of the mechanical structure cannot be neglected [5].

The second volume of this Special Issue of *Applied Sciences* aims to disseminate the latest research achievements, ideas, and applications of the modelling and control of mechatronic and robotic systems, with particular emphasis on novel trends and challenges. We invited contributions to this Special Issue on topics including (but not limited to): modelling and control, path and trajectory planning, optimization problems, collaborative robotics, mechatronics, flexible multi-body systems, mobile robotics, and manufacturing applications.

2. Modelling and Control of Mechatronic and Robotic Systems, Volume II

The papers collected in this Special Issue refer to a broad range of disciplines, such as robotic manipulation, mobile robots, service and social robots, cable-driven robotic systems, biomimetic robots, manufacturing, trajectory planning, and control. In most of the papers, numerical and simulation results are corroborated by experimental tests on real prototypes.

Several papers discuss mobile and autonomous systems. In [6], the kinematic and dynamic modelling, and the design of an omni-directional robotic platform for tunnel inspection is presented. That robot was built with the aim of automating the surveillance of a particle acceleration environment characterised by remaining radiations and spatial limitations. The authors of [7] illustrate the development and the experimental evaluation of a crawling terrestrial robot capable of rapidly adapting to the mission it must perform. The proposed prototype can provide a basis for future crawler robots used to detect, disarm, and dispose of explosive threats in extreme environments. Furthermore, the design and modelling of an amphibious spherical robot with fins is proposed in [8]. That robotic system is capable of both terrestrial and aquatic locomotion by exploiting the rolling motion of a spherical shell. Moreover, the spinning motion of the spherical shell is used to steer the robot efficiently and with agility.

The paper [9] presents a behaviour-control architecture for legged and climbing robots by considering their ability to perform self-reconfiguration after unforeseen leg failures. The proposed control approach is suitable for robots with different numbers of legs that move in any direction and inclination planes. Another control algorithm for biomimetic robots is illustrated in [10]. The authors provide a more detailed description of a data-driven control approach for snake manipulators composed of several modules coupled with universal joints. That control algorithm solves the problem of model uncertainty when the number of connecting rods of the serpentine manipulator increases and the environment becomes complex. Moreover, the model of a quadruped robot is considered in [11] to demonstrate the performance of an online foot-location-planning approach for legged robots. In particular, the illustrated strategy leverages model predictive control to solve the problem of large posture changes during gait transitions.

The work of [12] presents the design of the JET humanoid robot, characterized by low stiffness of the actuator modules, high motion capability, and wide range of motion of each joint. Experimental results, including stair climbing, egress from a car, and object manipulation, verify the robot performance and design concepts. In [13], the inverse kinematic problem of a multi-fingered anthropomorphic hand is solved using a genetic algorithm based on workspace analysis. Results show the effectiveness of the proposed approach and its potential application to many industrial robots.

Other works within this Special Issue focus on robotic systems with parallel kinematics. The authors of [14] present the design of a cable-driven parallel robot for non-contact tasks on planar surfaces, such as laser engraving on a paper sheet, inspection, and thermal treatment. A novel cable guidance system is illustrated, which allows for a simple kinematic model to control the manipulator. The work of [15] describes the design and implementation of a platform with six degrees of freedom used as a motion simulator. The inverse kinematic model of the robotic platform and its position-control system are implemented and verified with experimental results. Moreover, the authors of [16] present the control of closed-kinematic chain manipulators based on the concept of sliding mode control. The proposed controller is tested numerically on a planar manipulator with two degrees of freedom.

The paper [17] presents a method for estimation of the natural frequencies of a robotic Cartesian 3D printer based on the kinematics of the system. The approach can help the development of preliminary mechanical design of 3D printers and promises to be useful for emerging 3D printing technologies, which allows for new and sustainable manufacturing paradigms, especially within the framework of Industry 4.0 [18].

The papers [19,20] deal with automation applications in industry. In [19], the design and simulation of a fish-processing machine is shown. The system is introduced to process trout fish in four steps thanks to a vision-based approach. The effectiveness of the proposed design solution is verified through the fabrication of a physical prototype. The article in [20] presents a flow-rate estimation method for an automatic pouring machine for the casting industry. The approach is applied to a laboratory pouring machine to verify its performance in the case of uncertainties in the system model parameters.

The paper in [21] describes a hybrid position and force control architecture based on a finite state machine, which is applied to a robotic manipulator with five degrees of freedom. That control approach is tested on a waste management robotic systems adopted to the selective recycling of different types of materials.

In [22], a trajectory control for piezoelectric actuators based on artificial neural network is presented. The proposed scheme allows for compensating the unmodelled dynamics, uncertainties and perturbations.

Finally, the paper in [23] describes a theoretical method for designing thin motors using electromagnetic forces and electropermanent magnets for applications in portable electrical equipment. A prototype of a motor is fabricated to verify the results obtained with the theoretical approach.

3. Final Remarks

The second volume of this Special Issue collects interesting research papers focused on the modelling and control of mechatronic and robotic systems. This collection of works covers a wide range of applications with both numerical and experimental results. This Special Issue "*Modelling and Control of Mechatronic and Robotic Systems, Volume II*" demonstrates the level of interest in these topics and hints at future developments and challenges.

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References

1. Gasparetto, A.; Scalera, L. From the Unimate to the Delta robot: The early decades of Industrial Robotics. In *Explorations in the History and Heritage of Machines and Mechanisms*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 284–295.
2. Gasparetto, A.; Seriani, S.; Scalera, L. Modelling and Control of Mechatronic and Robotic Systems. *Appl. Sci.* **2021**, *11*, 3242. [CrossRef]
3. Trigatti, G.; Boscariol, P.; Scalera, L.; Pillan, D.; Gasparetto, A. A look-ahead trajectory planning algorithm for spray painting robots with non-spherical wrists. In *IFToMM Symposium on Mechanism Design for Robotics*; Springer: Berlin/Heidelberg, Germany, 2018; pp. 235–242.
4. Carabin, G.; Scalera, L. On the trajectory planning for energy efficiency in industrial robotic systems. *Robotics* **2020**, *9*, 89. [CrossRef]
5. Boscariol, P.; Gallina, P.; Gasparetto, A.; Giovagnoni, M.; Scalera, L.; Vidoni, R. Evolution of a dynamic model for flexible multibody systems. In *Advances in Italian Mechanism Science*; Springer: Berlin/Heidelberg, Germany, 2017; pp. 533–541.
6. Prados Sesmero, C.; Buonocore, L.R.; Di Castro, M. Omnidirectional Robotic Platform for Surveillance of Particle Accelerator Environments with Limited Space Areas. *Appl. Sci.* **2021**, *11*, 6631. [CrossRef]
7. Grigore, L.S.; Oncioiu, I.; Priescu, I.; Joita, D. Development and Evaluation of the Traction Characteristics of a Crawler EOD Robot. *Appl. Sci.* **2021**, *11*, 3757. [CrossRef]
8. Chi, X.; Zhan, Q. Design and Modelling of an Amphibious Spherical Robot Attached with Assistant Fins. *Appl. Sci.* **2021**, *11*, 3739. [CrossRef]
9. Hernando, M.; Alonso, M.; Prados, C.; Gambao, E. Behavior-Based Control Architecture for Legged-and-Climber Robots. *Appl. Sci.* **2021**, *11*, 9547. [CrossRef]
10. Hu, K.; Tian, L.; Weng, C.; Weng, L.; Zang, Q.; Xia, M.; Qin, G. Data-Driven Control Algorithm for Snake Manipulator. *Appl. Sci.* **2021**, *11*, 8146. [CrossRef]
11. Liu, X.; Ma, H.; Lang, L.; An, H. Online Foot Location Planning for Gait Transitioning Using Model Predictive Control. *Appl. Sci.* **2021**, *11*, 7866. [CrossRef]
12. Sim, J.; Kim, S.; Park, S.; Kim, S.; Kim, M.; Park, J. Design of JET Humanoid Robot with Compliant Modular Actuators for Industrial and Service Applications. *Appl. Sci.* **2021**, *11*, 6152. [CrossRef]
13. Lee, C.T.; Chang, J.Y.J. A Workspace-Analysis-Based Genetic Algorithm for Solving Inverse Kinematics of a Multi-Fingered Anthropomorphic Hand. *Appl. Sci.* **2021**, *11*, 2668. [CrossRef]
14. Mattioni, V.; Ida, E.; Carricato, M. Design of a Planar Cable-Driven Parallel Robot for Non-Contact Tasks. *Appl. Sci.* **2021**, *11*, 9491. [CrossRef]
15. Wei, M.Y. Design and Implementation of Inverse Kinematics and Motion Monitoring System for 6DoF Platform. *Appl. Sci.* **2021**, *11*, 9330. [CrossRef]
16. Duong, T.T.C.; Nguyen, C.C.; Tran, T.D. Synchronization Sliding Mode Control of Closed-Kinematic Chain Robot Manipulators with Time-Delay Estimation. *Appl. Sci.* **2022**, *12*, 5527. [CrossRef]
17. Kopets, E.; Karimov, A.; Scalera, L.; Butusov, D. Estimating Natural Frequencies of Cartesian 3D Printer Based on Kinematic Scheme. *Appl. Sci.* **2022**, *12*, 4514. [CrossRef]
18. Carabin, G.; Scalera, L.; Wongratanaphisan, T.; Vidoni, R. An energy-efficient approach for 3D printing with a Linear Delta Robot equipped with optimal springs. *Robot. Comput.-Integr. Manuf.* **2021**, *67*, 102045. [CrossRef]
19. Azarmdel, H.; Mohtasebi, S.S.; Jafary, A.; Behfar, H.; Rosado Muñoz, A. Design and Simulation of a Vision-Based Automatic Trout Fish-Processing Robot. *Appl. Sci.* **2021**, *11*, 5602. [CrossRef]
20. Sueki, Y.; Noda, Y. Experimental Verification of Real-Time Flow-Rate Estimations in a Tilting-Ladle-Type Automatic Pouring Machine. *Appl. Sci.* **2021**, *11*, 6701. [CrossRef]

21. Gal, I.A.; Ciocîrlan, A.C.; Mărgăritescu, M. State Machine-Based Hybrid Position/Force Control Architecture for a Waste Management Mobile Robot with 5DOF Manipulator. *Appl. Sci.* **2021**, *11*, 4222. [CrossRef]
22. Napole, C.; Barambones, O.; Derbeli, M.; Calvo, I. Advanced Trajectory Control for Piezoelectric Actuators Based on Robust Control Combined with Artificial Neural Networks. *Appl. Sci.* **2021**, *11*, 7390. [CrossRef]
23. Park, S.Y.; Song, B.; Baek, Y.S. A Theoretical Method for Designing Thin Wobble Motor Using an Electromagnetic Force and an Electropermanent Magnet for Application in Portable Electric Equipment. *Appl. Sci.* **2021**, *11*, 881. [CrossRef]