Editorial

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Biographical notes: Hassène Gritli received his PhD degree in 2013 and HDR degree in Electrical Engineering in 2020 from the National Engineering School of Tunis (ENIT), Tunisia. He is presently an Associate Professor at the Higher Institute of Information and Communication Technologies (ISTIC). He is also a Researcher at the Laboratory of Robotics, Informatics and Complex Systems (RISC), ENIT. He organised some Special Sessions on "Chaotic Systems" and "LMIs" and delivered also some Keynote Lectures on his research activity at some International Conferences. He was a (Lead) Guest Editor of some special issues in *International Journals on Robotics and Control Theory*.

Jawhar Ghommam is a Professor in Control Theory and Robotics at the National Institute of Applied Science and Technology, Tunisia. From September 2008 through September 2010, he had the privilege of regularly visiting a distinguished university at the Balearic Islands (Spain), where he served as a research contributor and Senior Lecturer on cooperative control algorithms and a lecturer on time-delayed systems. He also visited the GREPCI research group for two months. He is currently a Professor of control engineering at Sultan Quaboos University in Oman and occupies a permanent senior research position at the CEM Lab at Sfax-Tunisia.

Salwa Elloumi received her Master Degree of Automatic Control in 2000, the PhD degree in 2005 and the University habilitation (HDR) in 2014 in Electrical Engineering, all from the National High School of Engineers of Tunis. She is currently Professor in National Engineering School of Carthage and member of the research Laboratory of Advanced Systems at Polytechnic High School of Tunisia. Her current research interests include control of complex systems.

Giuseppe Carbone is an Associate Professor at DIMEG, University of Calabria and Chair of the IFToMM TC on Robotics and Mechatronics. He is a Key Member of LARM at University of Cassino (Italy). He has achieved several periods of research in several countries by (co-)supervising a large number of master and PhD students. His research interests cover aspects of Engineering Design, Mechanics of Robots, Mechanics of Manipulation and Grasp, Mechanics of Machinery with over 300 research paper outputs, 20 patents, and 16 PhD completions. He has been invited to deliver invited Keynote speeches and seminars at several international events.

Introduction

Control systems are designed to satisfy certain objectives like safety regulations, reliable production, disturbance rejection, and so on, and to operate under certain desired specifications and constraints for real-world problems. Advanced control techniques combine and extend methods established from several research fields such as control theory, mathematics, and computer science. Several advanced control approaches have been developed and applied for different types of robotic systems. However, due to the integration of robotic systems in the modern industry, in our daily life and in the physical and even the virtual world, it is required to explore new advanced and intelligent control methods for robots in order to meet the most challenging performance requirements.

The objective of this special issue is to search for the latest contributions to boost and enhance advanced control approaches for robotic systems. It is expected that novel design approaches will be designed and applied to real-world robotic system applications. This special issue is a collection of five peer reviewed and accepted papers. This special issue will provide a useful reference about recently developed approaches for the control of robotic systems.

Introduction to the special issue

This issue (special issue on ‘Intelligent and Advanced Control Methods in Robotic Applications’) collects three different contributions that extend selected works presented

at the 4th IEEE International Conference on Advanced Systems and Emergent Technologies (IC_ASET'2020), held at the National Engineering School of Tunis (ENIT), Tunisia, from December 15th to 18th, 2020, and also two other different contributions written by eminent researchers. Hereafter, the third, fourth and fifth papers are the extended versions of the accepted and presented conference papers.

The first paper, 'Adaptive iterative learning-based gait tracking control for paediatric exoskeleton during passive-assist rehabilitation', proposed a robust adaptive iterative learning control (AILC) scheme for a pediatric exoskeleton system. The dynamic model of such robotic system was formulated via the Euler-Lagrange principle. The stability proof of the adopted AILC scheme was achieved using the Lyapunov analysis method. Moreover, the robustness against external disturbances and parametric uncertainties was considered and hence validated via analytical and numerical results. Furthermore, the performance of the designed controller was compared with the classical iterative learning controller and the exponential reaching law-sliding mode control schemes. At the end, a portfolio of simulation runs was achieved showing that the AILC allows to track the desired gait trajectory.

The second paper, 'Gait stabilisation of an underactuated bipedal walker on steep slopes', a biped robot model was considered. Such biped robot is under actuated, which complicated the control scheme design. Author used an optimised design of the control parameters and also an appropriate reference trajectory for the tracking problem. An optimal switching controller was designed to track the reference trajectory as the target gait cycle, where the objective of this optimised controller is to push the bipedal gait to the target pattern by switching the control between hip-joint, ankle-joint and no control. Such reference trajectory was obtained from the passive dynamics study of the optimised bipedal walker on steep slope instead of from conventional level-ground walking. Moreover, author introduced and considered a foot-to-body mass ratio and optimised it along with the leg-length for maximising the distance traveled by the simplest bipedal walking model before falling down. As a result, it was shown that, under the optimised controller, the controlled biped model walks stably on steep-sloped surfaces. Thus, author demonstrated that the under actuated biped robot can walk stably on level-ground and down slopes between 0 and 30 degrees.

The third paper in this special issue is 'Path planning strategy for unmanned aerial vehicles based on a grey wolf optimiser', which is the first extended conference-based paper. This paper considered the path planning problem for Unmanned Aerial Vehicles (UAVs). Such issue was considered as a Large Scale Global Optimisation (LSGO) problem. Thus, to solve such problem, authors proposed an intelligent path planning strategy based first on the partition of the work area into multiple sub-environments and based also on a parameters-free Grey Wolf Optimiser (GWO) metaheuristic algorithm. As an application, a UAV drone was considered. For each formulated planning sub-problem of reduced dimension, a collision-free with shorter length sub-path was optimised under operational constraints of obstacles avoidance and paths straightness limitation. Authors used a cubic spline technique to smooth the generated flight route and make the planned path more appropriate for the UAV drone. The effects of the partitions size of the flight 3D static environment were investigated and hence discussed through demonstrative numerical simulations and nonparametric statistical analyses. To demonstrate the efficiency and therefore the superiority of the proposed GWO-based planning technique compared to other homologous metaheuristics from families of swarm intelligence and evolutionary algorithms, i.e., Water Cycle Algorithm (WCA),

Slap Swarm Algorithm (SSA), Particle Swarm Optimisation (PSO), and Differential Evolution (EA), authors achieved several simulation results. Thus, authors showed that the obtained results were satisfactory and very encouraging in the aim of a future practical implementation using the real-world prototype Parrot AR. Drone 2.0, as well as using the associated Matlab/Simulink software toolkit.

The fourth paper, 'Modelling, control and robustness analysis of a 2-DoF exoskeleton-upper limb system', presented a new Adaptive Gain Terminal Sliding Mode with Gravity Compensation (AGTSM-GC) control method of an exoskeleton-upper limb system. The considered robotic system has two degrees of freedom, and is in interaction with an upper limb, where such exoskeleton robotic system can be used for the rehabilitation of the human upper-limb. The main objective considered in this paper was the control of the flexion and extension movements of the shoulder and the elbow segments. Authors considered the presence of matched disturbances and uncertain parameters. Thus, the stability study of the closed-loop system subject to disturbances and using different control laws was realised. Furthermore, a comparison study between the different control laws to test their robustness, was achieved based on the Monte Carlo method. Finally, authors demonstrated via numerical simulations, the performance, effectiveness and robustness of the AGTSM-GC control law in the tracking of the desired trajectory.

The fifth paper in this issue is titled 'Improved filter design in internal model control: application to hybrid feed drive mechatronic system'. Here, authors proposed the Internal Model Control (IMC) method for over actuated mechatronic systems. To deal with the redundancy problem, the method of virtual outputs was adopted to square the system and hence to design the control law obtained by a well-defined inversion technique. Moreover, authors inserted an improved low-pass filter within the IMC structure in order to attenuate the sensitivity of the controller, as well as to improve the system performance and the robustness of the adopted structure towards external disturbances and parametric uncertainties. Furthermore, authors showed that the proposed filter design increased the bandwidth of the over actuated robotic system. Finally, and as an application, authors considered the hybrid feed drive mechatronic system. Thus, several simulation results by considering different scenarios have been carried out in order to evaluate the efficiency of the improved filter-based IMC structure.

Conclusion

The guest editors of the special issue 'Intelligent and Advanced Control Methods in Robotic Applications', would like to thank all the authors for submitting their valuable research works in this Special Issue and acknowledge the reviewers for their appreciated helps in reviewing the papers and providing positive and valuable observations to the authors. Finally, the guest editors would like to thank the Editor-in-Chief of the *International Journal of Intelligent Engineering Informatics (IJIEI)*, Professor Ahmad Taher Azar (Prince Sultan University, Kingdom of Saudi Arabia, and Benha University, Egypt) for his continuous support and help in systematising and coordinating the publication of this special issue.