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EDITORIAL

Editorial of the special issue: innovative robot design for special applications

Nowadays, robots are employed not only in traditional domains (such as industrial factories) but also in many other fields, where they can substitute or help human operators. Special applications are envisaged, and innovative robots to carry out these tasks should be designed. Novel approaches and techniques are therefore needed, in order to be able to build robotic devices that can deal with new issues and nonstandard requirements.

What has been mentioned above is one of the most crucial problems in robotics nowadays, and it has been discussed in many conferences and workshops of the robotic community, such as the International Conference of IFToMM Italy (IFIT).

Some of the papers published in this Special Issue are, indeed, extended versions of works presented at the 4th International Conference of IFToMM Italy (IFIT 2022), held in Naples (Italy) on September 7–9, 2022.

The topic of Innovative Robot Design for Special Applications encompasses many aspects, such as the functional design of robotic devices, the kinematic and dynamic modeling of mechanisms, the planning of profiles and trajectories, the study of vibrations, the control of mechanical systems, only to mention some.

The papers of this Special Issue deal with many of the above mentioned topics. Paper [1] discusses the analytical expressions of a motion profile characterized by elliptic jerk and compares it with other motion laws, such as trapezoidal velocity, trapezoidal acceleration, cycloidal, sinusoidal jerk, and modified sinusoidal jerk. It is shown that the proposed motion law provides a good compromise between different performance indexes, namely settling time, and maximum absolute values of velocity and acceleration.

Issues related with the design of special robots are considered in ref. [2], where the design and kinematic representation of a soft robot in a simulation environment is carried out. Modeling soft robots is indeed a challenging task, since classical modeling techniques are suitable for rigid link mechanisms, that have a limited number of degrees of freedom (DOFs), while robots with flexible links have an infinite number of DOFs. The authors propose a novel procedure for modeling of soft robots, based on the piecewise constant curvature approach, which is then validated through application to a soft biomimetic robotic squid designed for underwater manipulation.

The design of a complex robot for special tasks is carried out in ref. [3], where a new humanoid robotic platform implementing additive manufacturing techniques is considered. Joint configurations, as well as the range of motion, of the lower body of the humanoid robot are discussed. Moreover, finite element analysis is performed to check the structural integrity and to avoid structural failures in the robot.

Paper [4] deals with another issue related to robots for special applications, namely the design of nonlinear stiffness elastic actuators (NSEAs). In this paper, a general design method of torsional compliant mechanism through given discrete torque-deflection points is proposed, then the dimensional parameters of proposed compliant mechanism are designed satisfying the condition of the given torque-deflection points. The method is finally validated by means of dedicated experiments on a NSEA built by the authors.

When designing new robots, a fundamental issue is the singularity of the kinematic chain. In ref. [5], the kinematic analysis and the synthesis of a five-bar linkage with symmetrical structure and singularity-free dexterous workspace is carried out. A complete model is developed, which allows to design a singularity-free mechanism, which is then built and experimentally tested with success.

Paper [6] studies a new load-balancing method, based on a passive damper mechanism, to overcome the problems arising when a heavy load is applied to the parallel manipulators, in particular inaccuracies while positioning the end-effector or unbalanced dynamic forces in the legs. The designed mechanism compensates the inertia effects, while countering the static inaccuracies in the parallel mechanism.

Mobile robotics is a field where many special applications can be envisaged, hence a lot of scientific research is aimed at studying innovative techniques to be applied to mobile platforms and autonomous navigation. In this Special Issue, paper [7] proposes a comparison of open-source LiDAR and inertial measurement unit-based simultaneous localization and mapping approaches for 3D robotic mapping, both for indoor and for outdoor navigation.

In ref. [8], the multibody model of a new passive articulated suspension tracked robot is presented. This multibody model allows the system performance to be evaluated in advance for fine-tuning of the design parameters and using different configurations, for example, with active and locked suspension. The digital twin is then validated through experimental tests.

Paper [9] studies a modified rocker-bogie suspension for robotic rovers, designed for overcoming the problems due to the variation of the operation conditions of the rover (such as sloping ground, uneven ground surface, or different payload position), which can seriously affect the weight distribution. The proposed suspension can regulate the distribution of vertical loads among the wheels by means of a torsion spring, with adjustable preload, arranged between rocker and bogie.

Autonomous navigation issues are not limited to mobile robots, but are also relevant in special application of other types of robots. In ref. [10], a novel collision avoidance system designed for the motion planning of Quad-SCARA in multipoint grasping state is proposed. The system, based on buffered Voronoi cells, is validated through complex experimental tests, such as folding and spreading a handkerchief.

Cable robots are often used for special applications, such as rehabilitation of injured patients. In ref. [11], the forced vibrations of cable-suspended rehabilitation robots, generated by rehabilitation exercises, are investigated. A two-cable planar model for the study of transverse vibrations is developed, taking into account stiffness and damping of the patient's arm. It is found that the cable system exhibits a simple linear behavior when excited by robot motion and a non-linear behavior when excited by cable motion.

Paper [12] presents a novel cable-driven parallel robot with the aim of rehabilitating/exercising young and disabled children in drawing and writing tasks. The robot has a pyramidal topology, so as to provide the required three active translational DOFs with a redundant set of five cables in a compact portable shape. Moreover, the robot has several attractive features: it is inexpensive, easy to control, easy to move to any place at home or school as it is fitting a home desk or classroom table; in addition, it has a specific user interface allowing both continuous and intermittent trajectories.

A medical robotic application is considered in ref. [13], where instrumentation development and results for evaluating implant performance in the stabilized cranio-vertebral junction (CVJ) after surgical procedures are reported. Pose estimation of the CVJ region is estimated using a monocular vision-based setup, so as to evaluate the performance of vision-based intervertebral motion estimation of the CVJ in the Indian population, particularly in older people.

The last paper of this Special Issue [14] describes the design and the prototyping of an automatic wire stripping robot for use in a 10 kV power grid. High-voltage cable stripping is mostly done manually, which is inefficient and poses serious safety risks. The mechanical structure of the stripping robot is designed for installation on the insulating rod based on the working environment of 10 kV overhead cables.

References

[1] D. Stretti, P. Fanghella, G. Berselli and L. Bruzzone, "Analytical expression of motion profiles with elliptic jerk," *Robotica* **41**(7), 1976–1990 (2023). doi: 10.1017/S0263574723000255.

[2] H. Emet, B. Gür and M.İ.C. Dede, "The design and kinematic representation of a soft robot in a simulation environment," *Robotica* **42**(1), 139–152 (2024). doi: 10.1017/S026357472300139X.

[3] A. J. Fuge, C. W. Herron, B. C. Beiter, B. Kalita and A. Leonessa, "Design, development, and analysis of the lower body of next-generation 3D-printed humanoid research platform: PANDORA," *Robotica* **41**(7), 2177–2206 (2023). doi: 10.1017/S0263574723000395.

[4] W. Ju, B. Li, R. Kang, S. Zhang and Z. Song, "Design of a torsional compliant mechanism with given discrete torque-deflection points for nonlinear stiffness elastic actuator," *Robotica* **41**(9), 2571–2587 (2023). doi: 10.1017/S0263574723000528.

[5] T. Demjen, E.-C. Lovasz, M. Ceccarelli, C. Sticlaru, A.-M.-F. Lupuţi, A. Oarcea and D.-C. Silaghi-Perju, "Design of the five-bar linkage with singularity-free workspace," *Robotica* **41**(11), 3361–3379 (2023). doi: 10.1017/S0263574723001042.

[6] A. X. R. Prasad and M. Ganesh, "Design, static analysis, and dynamic system modeling of 3-PPRS parallel manipulator with load-balancing UPS leg," *Robotica* **41**(9), 2735–2753 (2023). doi: 10.1017/S0263574723000632.

[7] D. T. Fasiolo, L. Scalera and E. Maset, "Comparing LiDAR and IMU-based SLAM approaches for 3D robotic mapping," *Robotica* **41**(9), 2588–2604 (2023). doi: 10.1017/S026357472300053X.

[8] A. Grazioso, A. Ugenti, R. Galati, G. Mantriota and G. Reina, "Modeling and validation of a novel tracked robot via multibody dynamics," *Robotica* **41**(10), 3211–3232 (2023). doi: 10.1017/S0263574723000966.

[9] C. Cosenza, V. Niola, S. Pagano and S. Savino, "Theoretical study on a modified rocker-bogie suspension for robotic rovers," *Robotica* **41**(10), 2915–2940 (2023). doi: 10.1017/S0263574723000656.

[10] X. Sun, K. Ishida, K. Makino, K. Shibayama and H. Terada, "Development of the "Quad-SCARA" platform and its collision avoidance based on Buffered Voronoi Cell," *Robotica* **41**(12), 3687–3701 (2023). doi: 10.1017/S0263574723001236.

[11] G. Zuccon, A. Doria, M. Bottin, R. Minto and G. Rosati, "Vibrations of cable-suspended rehabilitation robots," *Robotica* **41**(12), 3702–3723 (2023). doi: 10.1017/S0263574723001248.

[12] M. Khadem, F. Inel, G. Carbone and A. S. Tich Tich, "A novel pyramidal cable-driven robot for exercising and rehabilitation of writing tasks," *Robotica* **41**(11), 3463–3484 (2023). doi: 10.1017/S026357472300111X.

[13] M. Zubair, S. Kansal and S. Mukherjee, "Investigating the vision-based intervertebral motion estimation of the Cadaver's craniovertebral junction," *Robotica* **41**(10), 2907–2914 (2023). doi: 10.1017/S0263574723000644.

[14] J. Zhong, Z. Wang, S. Hu and Z. Han, "A novel 10 kV high-voltage cable stripping robot's mechanism design and analysis," *Robotica* **41**(9), 2605–2624 (2023). doi: 10.1017/S0263574723000565.

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