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Editorial

Special Issue "Legged Robots into the Real World"

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In the landscape of intelligent systems and robotics, legged robots stand out as a fascinating fusion of biological inspiration and engineered design. Modelled on diverse biological locomotion strategies, these mechanical entities aim to traverse the most challenging terrains and operate in environments that conventional wheeled robots find daunting. Although substantial strides have been made with quadruped robots such as Boston Dynamics Spot, ANYbotics ANYmal, and Unitree B1, transitioning from controlled experiments to robust real-world applications brings forth complex scientific and technological hurdles. These challenges involve not only robust mechanical design and dynamic locomotion, but also sophisticated control schemes, advanced sensing and state estimation, efficient energy management, and seamless interaction with the environment and other systems. This Special Issue delves into these multifaceted challenges, with each paper offering an original and significant contribution aimed at enhancing the capabilities and potential of legged robots in real-world scenarios.

A cornerstone of humanoid robotics, the dynamic balancing of high degrees of freedom systems, presents an exacting test of control design's robustness. Paper [1] embarks on an in-depth comparative study of three control design approaches to humanoid balancing. Through robust benchmarking using key performance indicators in controlled scenarios, the authors have not only demonstrated the efficacy of their proposed strategies, but also established a valuable framework for evaluating and comparing dynamic balancing techniques. This contribution will be instrumental in steering future research in humanoid balance control towards more robust and human-like responses.

Optimization strategies in model predictive control form a core component of advanced robotic control, shaping a robot's interaction with its environment in real-time. Paper [2] unfolds an innovative optimization-based reference generator for the model predictive control of legged robots. The proposed methodology tackles the intricate problem of balancing the robot's dynamic behaviour with the requirements of a specific goal and environmental disturbances. This advancement paves the way for more reliable and adaptable real-world deployment of legged robots, extending their reach into dynamic and unpredictable environments.

Navigating on slippery surfaces, a prevalent scenario in outdoor settings, presents another complex challenge in this field. Paper [3] takes a data-driven approach to this issue, incorporating a neural network and a linear model predictive controller to improve the robot's trajectory accuracy and safety on low-friction terrain. This solution offers insights into the potential benefits of data-driven methods in enhancing the resilience and adaptability of legged robots on diverse and challenging terrains.

The issue of real-time foot placement decision-making while navigating diverse terrains is addressed in paper [4]. The authors propose a unique navigation strategy that integrates ground reaction forces and online artificial potential fields to guide the robot's foot placement, successfully navigating complex terrains such as agricultural fields. This approach broadens the horizons for legged robots' deployment in various practical applications, particularly in environments where terrain conditions change dynamically.

Lastly, paper [5] brings forth an innovative trajectory optimization method for legged robots, aimed at imitating a broad array of animal movements. This method's integration with a model-based controller demonstrates the versatility and agility of legged robots in replicating various motor skills, such as trotting, pacing, turning, and side-stepping, both in simulations and real-world settings.

In conclusion, this Special Issue makes significant strides towards realizing the vision of integrating advanced intelligent robotic systems into legged robots for practical applications. Each paper within this collection presents novel methodologies, explores groundbreaking ideas, and offers valuable benchmarking tools for future research. These advancements inspire the journey towards achieving a future where legged robots are commonplace in daily life, unlocking their full potential in real-world applications. We hope this Special Issue will serve as a stimulus for further research and innovation in the field of legged robotics, propelling us closer to this transformative vision.

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References

1. Castano, J.A.; Humphreys, J.; Hoffman, E.M.; Talavera, N.F.; Sanchez, M.C.R.; Zhou, C. Benchmarking Dynamic Balancing Controllers for Humanoid Robots. *Robotics* **2022**, *11*, 114. [CrossRef]
2. Bratta, A.; Focchi, M.; Rathod, N.; Semini, C. Optimization-Based Reference Generator for Nonlinear Model Predictive Control of Legged Robots. *Robotics* **2023**, *12*, 6. [CrossRef]
3. Arena, P.; Patanè, L.; Taffara, S. A Data-Driven Model Predictive Control for Quadruped Robot Steering on Slippery Surfaces. *Robotics* **2023**, *12*, 67. [CrossRef]
4. Morlando, V.; Cacace, J.; Ruggiero, F. Online Feet Potential Fields for Quadruped Robots Navigation in Harsh Terrains. *Robotics* **2023**, *12*, 86. [CrossRef]
5. Li, T.; Won, J.; Cho, J.; Ha, S.; Rai, A. FastMimic: Model-Based Motion Imitation for Agile, Diverse and Generalizable Quadrupedal Locomotion. *Robotics* **2023**, *12*, 90. [CrossRef]